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RESIDENTS HEALTH STUDY REPORT

for the

UPPER OTTAWA STREET LANDFILL SITE STUDY

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SUMMARY

This report describes the design and conduct of an historical prospective morbidity survey of a cohort of residents living adjacent to the Upper Ottawa Street Landfill Site in Hamilton, Ontario. The objectives of the research were to determine whether there were excesses of certain adult, child, and maternal-child health problems among these residents; to assess the likelihood of a causative relationship between any excess health problems and exposure to the landfill site; to assess whether such health problems might continue to affect residents' well-being since closure of the landfill; and to provide a basis for any recommendations to the Committee regarding further medical follow-up. The study involved an interviewer administered health questionnaire, followed by assessment of recall bias through medical chart abstraction. Data were analyzed for strength of association; consistency with the workers' study; risk gradient by duration of residence and proximity to the landfill; risk occurring first when the landfill was open; evidence that less healthy people moved to the area; specificity; and the absence of recall bias. Two crucial questions needed answering in relation to the time period when the landfill site was open:

1. Was any association between landfill site exposure and increased rates of various health problems a valid one?
2. What was the likelihood that such a valid association was caused by chemical exposures from the site?

The above mentioned criteria were largely fulfilled in relation to certain "narcotic" (i.e., pertaining to the central nervous system) "mood", "skin", and "respiratory" conditions among adults. They were partially fulfilled with respect to "red, itchy eyes". Among children, the applicable criteria were largely fulfilled for "narcotic", "skin", "mood", and "red, itchy eyes". However, the strength of evidence for valid associations between residents adjacent to the landfill and these conditions is reduced by three principal problems. These are: the high refusal rate among the control population; socioeconomic status differences between the study groups; and the fact that the conditions found in excess are imprecisely defined and potentially interchangeable with other conditions. Offsetting these problems

are the multiple criteria used to assess the hypotheses, which were identified and evaluated according to preset rules.

In summary, the associations between residence adjacent to the landfill site and the specified health problems appear to be valid. The problem, however, is that the causative agent or agents have not been identified. Two competing causes may be proposed:

1. some airborne contact with a combination of vapours, fumes, and particulate matter emanating from the landfill site, and with direct skin exposure from recreational activities in and around the landfill.

2. the perception of exposure and, therefore, of risk may have led to an increased tendency on the part of exposed residents to notice new health problems, become concerned about them and subsequently report them in a health survey.

During the course of this study, indirect evidence accumulated which supports each possible causal mechanism. Six lines of reasoning support a chemical mechanism:

1. The gradient of risk by proximity to the landfill site and duration of residence would be difficult to explain on the basis of perception of risk alone.
2. The symptoms and the organ systems affected were biologically plausible on the basis of exposure to substances known to be present in the landfill.
3. The consistency of symptoms between workers and residents, despite lack of social contact between them and differing attitudes to potential for risk expressed by members of the two groups.

4. The fact that the conditions found in excess in our study were much different from those found in excess on the residents' original health survey.
5. The absence of evidence of recall bias on medical chart abstraction.
6. The fact that the conditions which developed during the period when the landfill was open are disappearing at a similar rate among exposed residents and controls suggest an absence of "learned illness" behaviour.

By contrast, there are four lines of reasoning which strengthen the case for a perceptual mechanism:

1. An absence of evidence that residents and workers were exposed to airborne concentrations of the substances of interest sufficient to cause health problems found in excess.
2. The health problems found in excess in this study could theoretically be explained by behavioural mechanisms.
3. Those problems which affect the valdity of the associations themselves (e.g., refusal rate of controls and differences in socioeconomic status between the study groups) could also influence perceptual and behavioural factors that affect one's experience and recall of symptoms.
4. Some subanalyses comparing patterns of health problem reports between migrators from the landfill area and non-migrators may be more easily explained by perception of exposure to chemical emissions than by exposure itself. However, there are alternate explanations that also need to be considered and these are outlined in the text of this report.

It is likely that both mechanisms contributed to the association between landfill site exposure and the health problems found in excess in this study. It is the opinion of the authors of this report that the factors supporting

chemical causation cannot be ruled out on the basis of this study and appear to us to be more convincing than those which support a perceptual mechanism.

This study did produce some important negative findings. There was no evidence of adverse reproductive outcomes related to exposure to the landfill site. There was no evidence of increases in major chronic diseases among exposed residents. Also, there is no convincing evidence that exposure to the landfill site after it was closed and capped has led to health problems. Because of the short follow-up time this study cannot address the question of cancer risks. Ths would require a follow-up of the cohort of exposed residents over the next 10 to 20 years to assess their cancer experience through incidence and mortality registries.

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I. INTRODUCTION

This report describes the design and conduct of an historical prospective morbidity survey of residents living adjacent to the Upper Ottawa Street Landfill Site in Hamilton, Ontario. The study compared the self-reported health histories of those living within 750 metres of the landfill site between 1976 and 1984 with residents of another Hamilton community matched by dwelling size and type, construction dates, and property resale values. The health histories were validated by medical chart abstraction of a sample of the health problems from the questionnaire. The sample of exposed residents was divided into three subgroups: (1) those who lived near the site during peak years of waste disposal (1976-1980) and still lived there at the time of the interview; (2) those who lived there during the time of peak disposal but subsequently moved; and (3) those who moved in after disposal ceased. The first subgroup was further divided by proximity of residence to the landfill (250 to 500 metres from the dumpface, and 500 to 750 metres from the dumpface), and duration of residence adjacent to the site during the peak disposal period (three or more years, one-to-three years). These subgroups formed the bases for sampling and analyses of the health survey.

The objectives of this research were:

1. to determine whether the incidence rates of certain adult, child, and maternal-child health problems were greater among the present and former residents living near the landfill than among a control population,

2. to assess the likelihood of a causative relationship between any health problems found in excess among the residents and their exposure to the landfill site,

3. to assess whether or not any health problems found in excess among the exposed residents would likely continue to affect their well-being over time,

4. to provide a basis for any recommendations to the Committee regarding the feasibility, validity, and efficiency of any strategies for medical evaluation or long-term monitoring of the exposed populations (worker or resident).

II. BACKGROUND

The Upper Ottawa Street Landfill Site is located near the slope of the Niagara Escarpment in Hamilton, Ontario (Figure 1). It began as a rural quarry dumpsite in the 1950s, situated on a permeable fractured bedrock of dolomite, shale, siltstone, and limestone. Now it is a 90 foot high mound covering about 40 acres. The site is bordered on the north side by the Red Hill Creek. To the east is a conservation area, and a light industrial park is located across the street on the south side. (Figure 2). Throughout the 1950s and 1960s, a small collection of houses was found along Stonechurch Road, within 750 metres south of the dumpface. By the late 1970s, these had been largely removed, to make way for light industrial development. Development of large residential areas to the west, north, and northeast of the site began in the early 1970s and continued into the early 1980s. These consisted of single detached dwellings and townhouses which were built as close as 250 metres from the dumpface. Most of the study population are inhabitants of this area.

From the early 1950s until it was closed in 1980, the Upper Ottawa Street Landfill Site received a large variety of domestic and commercial waste as well as solid and liquid industrial wastes.[1] By the mid-1960s, as much as five truck loads a day of industrial waste was being received by the landfill. However, the annual tonnage increased markedly during the 1970s. Available records suggest that approximately 225,000 gallons of liquid wastes were disposed of in the site in 1970. It would appear that larger volumes of liquid waste began entering the landfill in 1976 with the opening of a solidification operation. According to records, the largest volumes of liquid wastes appear to have been disposed of during 1978: approximately 8 to 12 million gallons.[2] The site was closed to landfilling in 1980. Between November 1980 and June 1981, it was covered by a layer of steel industry wastes, ranging from a depth of up to 20 feet on the flat top of the landfill to only a few feet on the steep slopes. This was then covered with a thin clay cap.

Figure 1 - LOCATION OF THE UPPER OTTAWA STREET LANDFILL

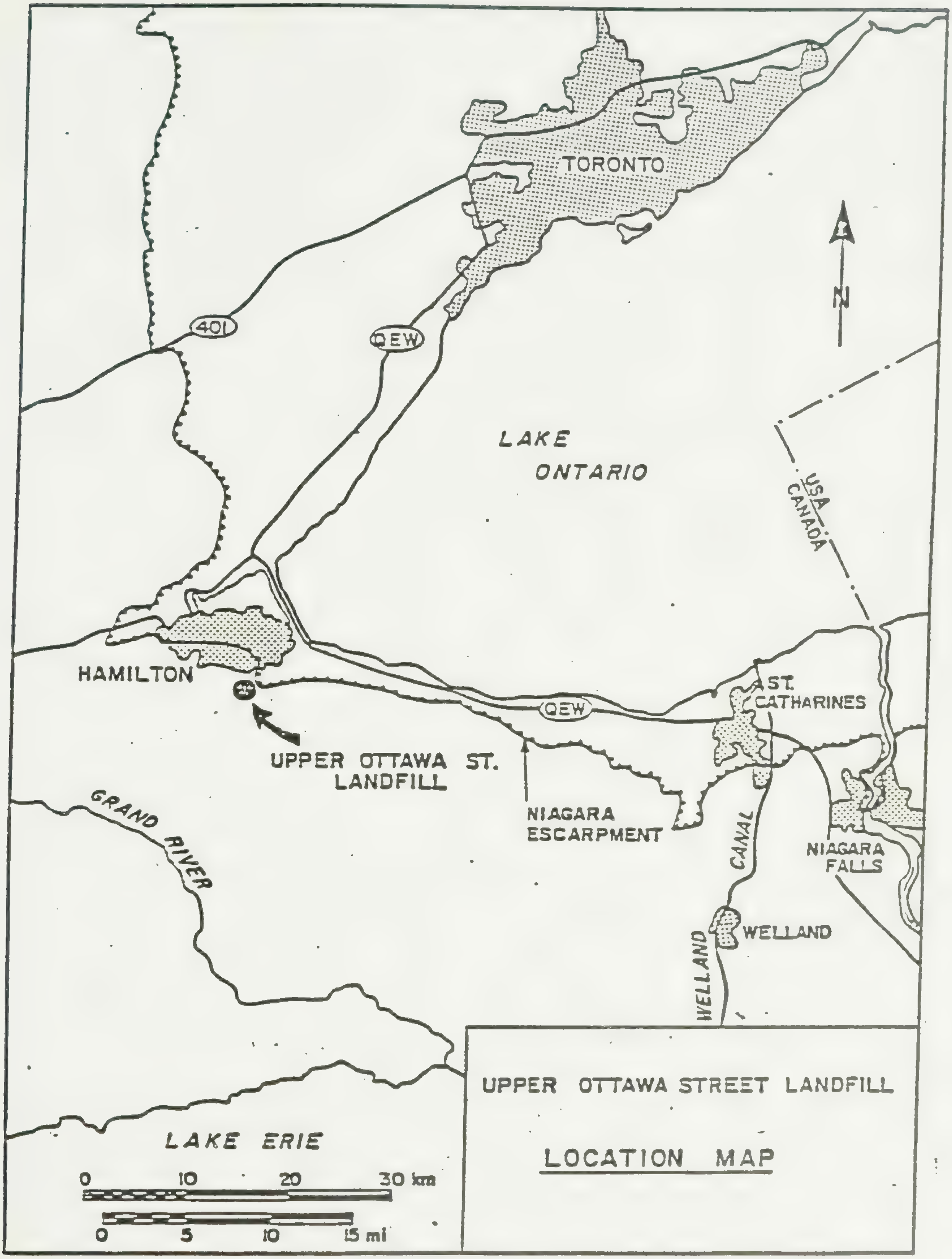
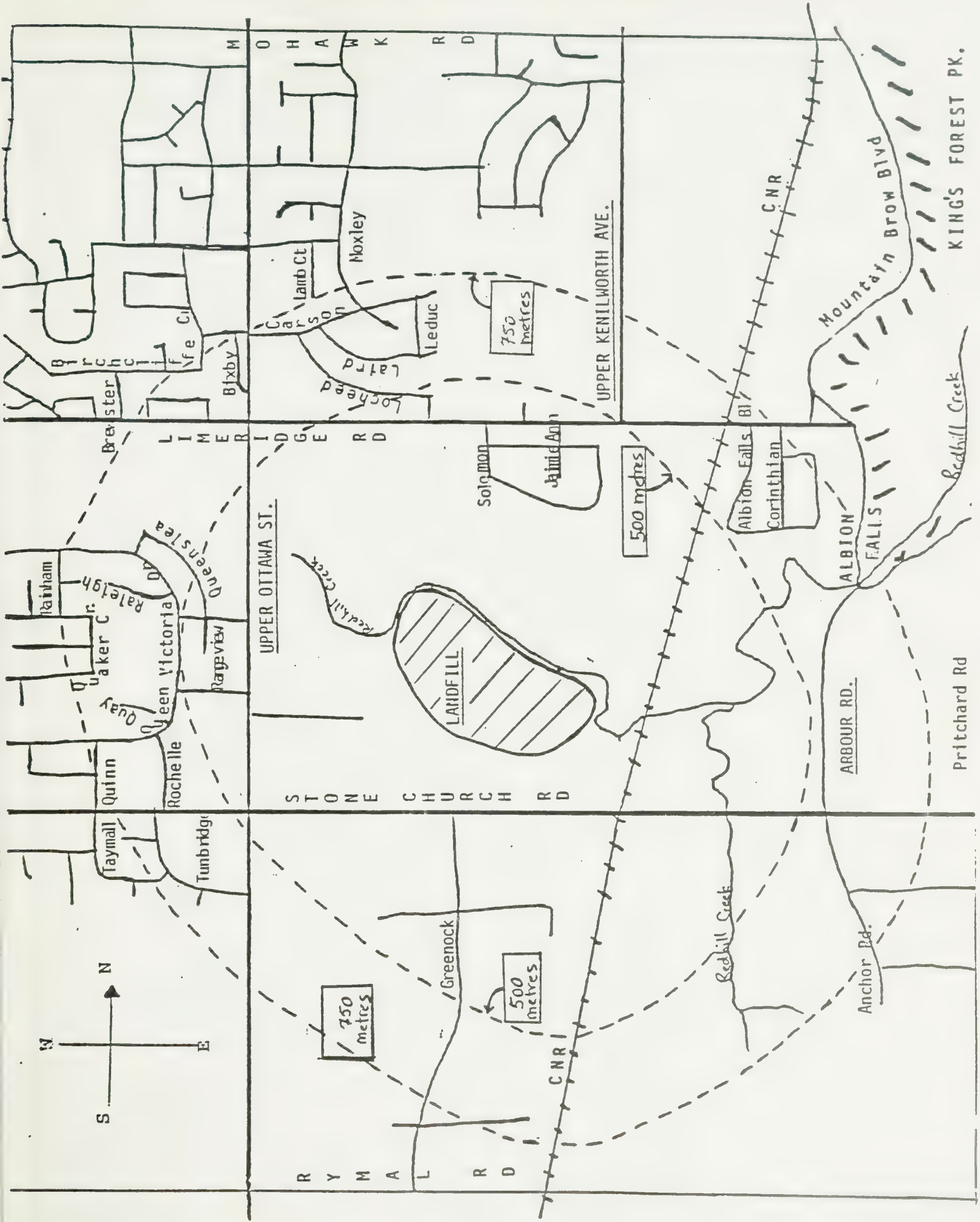


FIGURE 1: MAP OF AREA NEAR THE UPPER OTTAWA STREET LANDFILL SITE



While the site was active, the residents had three sources of potential exposure to landfill site emissions.

1. Airborne exposure to vapours, fumes, dusts, and ash may have resulted from open air release of volatile substances and solid industrial residues at the landfill, as well as from open-air burning.

2. Airborne deposition of landfill site emissions on residential properties left open the possibility of contact through soil, window cleaning or other domestic activities.

3. Use of parkland areas adjacent to the Red Hill Creek, and use of the Red Hill Creek itself, left open the potential for recreational contact with site emissions.

The possibility of adverse health effects resulting from exposure to the Upper Ottawa Street Landfill Site was raised publicly in 1978,[3] when residents of the adjacent subdivision began to draw parallels between the Love Canal experience and their own. In 1979, an informal survey of health effects among a small group of resident households was carried out by some of the organizers of the residents' group.[4] (see Appendix A). It was suggested that there were excesses of sore throats, colds, headaches, earaches, "bleeding" and "kidney problems" among the residents when compared to a control survey. These results received widespread criticism as being unscientific because of the way in which the survey was conducted and the enormous potential for bias intrinsic to a special interest group studying itself.

In October, 1980, the Ministry of Health announced that it would fund an investigation of the Upper Ottawa Street Landfill Site, as requested by the Regional Municipality of Hamilton-Wentworth.[5] An Upper Ottawa Street

Landfill Site Study Committee was established with three terms of reference. These included:

1. To investigate the validity of studying, and as appropriate, to recommend to the Ministry of Health that studies be undertaken on:

    (a) the chemical nature of the materials deposited in the landfill site and their changes in that environment;

    (b) the migration of chemical substances away from the area;

    and to consider the findings of any such studies.

2. To advise the Minister as to the Committee's findings and as to the possible existence at or about the landfill site of a hazard to human health.

3. To consider such other matters brought out in the course of the Committee's activities which the Committee deems relevant to the terms of reference.[6]

The Committee began its investigation in April of 1981 by formulating a sequential study approach. This consisted of efforts to:

1. determine from records what was buried in the landfill itself,
2. examine the environment around the landfill for chemicals, and
3. examine the health of workers and residents to determine what ill health effects, if any, might be attributable to exposure to landfill chemicals.

The Committee recognized that the investigation was the first of its kind in Ontario and would be viewed as a prototype with application to problems at other landfills in the future.

The Committee and its Advisory Health Group decided that a health study of landfill workers should precede the residents' health study. The reasons for this were:

1. The workers represented a potentially high dose exposure subgroup, and might therefore be particularly vulnerable to any potential health impact associated with exposure to the landfill.

2. Apparent increases in specific morbidity found in a workers' study could receive special attention in the residents' study, thereby reducing the multiple comparisons problem inherent in the analysis of a general morbidity survey.

3. Consistent results from two separate health surveys with different designs might be more credible than one study which tried to combine workers and residents in one protocol.

The Committee proceeded with the worker health study, recognizing that it would not be straightforward. There was a paucity of scientific papers in the refereed literature concerning the methodology and conduct of similar studies at other landfill sites. The complex toxicological nature of the landfill and the subjective nature of the residents' initial complaints made it difficult to identify a short list of health problems of particular interest. There were great opportunities for bias due to the complex political nature of the problem. But none of these difficulties precluded the design and execution of a study which could indicate the possible existence of human health hazards at or about the landfill.

By the time the residents' study was being designed, certain additional problems came into focus:

1. The nature and intensity of chemical exposures among the residents could not be reliably reconstructed through a multidisciplinary

evaluation including botanic, hydrogeological, geophysical, engineering, and chemical toxicologic studies. However, by the time of completion of this study, a variety of compounds had been identified in the landfill which were known respiratory irritants, neurotoxins, and skin irritants/sensitizers in the industrial context. (See Appendix B).

2. The identification and follow-up of the residential population was complicated by a high rate of in and out migration from the housing developments adjacent to the landfill site.

3. Some of the health problems of concern, in particular those related to birth defects, were expected to be too uncommon for adequate study power to be achieved among a population living sufficiently close to the landfill site to be deemed "exposed".

Table 1 shows the health problems found in excess among the landfill site workers, compared with unexposed controls. These form the hypothesis base for the residents' study. The credibility of each hypothesis from the workers' study is rated "high", "moderate", or "low" depending upon whether the association between landfill exposure and the health problem met the criteria specified in the table. Those associations with "high" and "moderate" credibility served as the main hypotheses to be tested by the adult portion of the residents' health survey. Because of differences in the format of the residents' and workers' study questionnaires, the nine high and moderate credibility associations (Table 1) corresponded to 19 individual health problem hypotheses and four organ-system group hypotheses in the residents' study (Table 2). In addition, three other groups of conditions were identified as hypotheses based either on the residents' original health survey (Appendix B), or the opportunity to study congenital and childhood effects. These include:

1. Among children: the same respiratory, skin, narcotic, and mood conditions as identified for the adults (Table 2).

Table 1: Summary of Results of the Hypothesis Generating Exercise of the Workers' Study*

Condition	Biologic Plausibility	Strength of Association		No Evidence of non-conservative recall bias	Time Cluster (1970-75) or (1976-80)	Risk Gradient by Intensity of Exposure	Overall Credibility of the Association
		$RR \geqslant 2.0$*	$p < 0.05$				
Chronic Bronchitis	+	+	+	+	+	++	High
Difficulty Breathing	+	-	-	+	+	+	Moderate
Daily Cough	+	+	+	+	+	++	High
Combined Respiratory	+	+	+	+	N/A**	++	High
Combined Cardiac	+	-	-	+	+	-	Low
Skin Rash	+	-	-	+	+	+	Moderate
Combined Skin	+	-	-	+	N/A**	+	Moderate
Red, Itchy Eyes	+	?	?	+	-	+	Low
Arthritis	-	-	-	+	+	-	Low
Narcotic Symptoms	+	+	+	+	+	++	High
Mood Disorders	+	+	+	+	+	++	High
Tremors, cramps, spasms	+	?	?	+	-	-	Low
Muscle Weakness (arms & legs)	+	-	-	+	+	++	Moderate

+= monotonic trend
++= $p < 0.05$

* Adapted from the Report of the Workers' Health Study of the Upper Ottawa Street Landfill Site Study.
** Not analyzeable

? = insufficient data for analysis

Table 2: Correspondence between Workers' Study Conditions and Residents' Study Hypotheses

	Conditions Found in Excess Among Exposed Workers	Health Problems Eligible for Hypothesis-testing in Residents' Study
1.	Chronic Bronchitis	(a) Attacks of bronchitis (b) Chronic bronchitis
2.	Difficulty breathing	(c) Shortness of breath
3.	Daily cough	(d) Cough and phlegm
4.	Combined bronchitis, emphysema, difficulty breathing, daily cough	(e) Combined (a) to (d)
5.	Skin rash	(a) Recurrent or severe problems with skin rashes or hives
6.	Combined skin rash, unusual acne	Recurrent or severe problems with (b) ... scaly, dry, or itchy skin (c) ... unusual acne (d) ... boils, warts, cycsts (e) White or dark patches on the skin Combined (a) to (e)
7.	Combined headaches, dizziness lethargy, balance problems (Narcotic Symptoms)	(a) frequent or severe headaches (b) frequent dizziness or blurred vision (c) constant fatique, lethargy, drowsiness (d) problems with balance, co-ordinations, reaction time, clumsiness Combined (a) to (d)
8.	Combined anxiety, depression, trouble sleeping, irritability, restlessness (Mood Symptoms)	(a) trouble sleeping (b) frequent feelings of anxiety or depression (c) frequent feelings of irritability (d) frequent feelings of hyperactivity, restlessness, trouble sitting still (e) learning or memory disorders Combined (a) to (e)
9.	Muscle Weakness (arms & legs)	Muscle Weakness (arms, legs, hands, feet)

2. Among children and adults:
    - hayfever
    - asthma
    - 5 or more colds a year
    - wheezy or whistling chest for most days or nights throughout the year
    - nosebleeds (not from injury)
    - unusual nose irritation or nasal discharge
    - throat infections
    - prolonged, irritated, sore throat
    - red, itchy, watery, sore, dry or inflamed eyes
    - numbness, tingling, prickling or loss of sensation on:
      legs or feet
      arms or hands

3. Among adult females: adverse reproductive outcomes.

The residents' study is meant to be an hypothesis-testing study. The results of the workers' study and the sampling strategy allow us to evaluate hypotheses for consistency, strength of association, dose-response gradient by proximity to the landfill site and duration of residence, and potential for migrator or recall biases.

The health problem hypotheses from the workers' study and those identified on other grounds were meant to be handled separately in the analysis and conclusion-drawing phases of this study. The presumption is that hypotheses derived from an hypothesis-generating study (ie. from the workers' study) have a higher pre-study probability of being causative than others derived in less rigourous ways. By analogy between epidemiologic study and diagnostic testing, evidence of a "positive" outcome related to an hypothesis generated from the workers' study should also mean a higher post-

test probability of causation than a "positive" outcome related to an hypothesis from a less rigourous source. Thus the main analysis of this study was based on the hypotheses from the workers' study, and the other hypotheses were given secondary consideration ("secondary hypotheses").

III. LITERATURE REVIEW

The morbidity survey, based on self-reports of individuals living and working near a point source of mixed industrial waste, has become an important element in the investigation of the health status of exposed populations.[7,8,9] In Toronto, Spitzer et al[10] compared the health status of residents living in the Junction Triangle neighbourhood (a heavily industrial area) with a control neighbourhood from the same city. The investigators gathered information about a series of cardinal symptoms thought to be especially relevant to the type of exposure experienced by residents of the Triangle in addition to information about general health status, including recent conditions, chronic health problems, activity limitations, and health care utilization.

No differences were found in patterns of health among adults in the two areas. However, statistically significant and clinically important differences were detected among children for certain cardinal symptoms. These included itchy, burning or running nose (not due to colds) and throat irritation. The authors concluded that there was enough evidence of unfavourable health experience among children in the Junction Triangle to warrant a clinical evaluation of their health status.

A 1983 study of residents exposed to a variety of hazardous wastes emanating from a waste processing plant in Lowell, Mass.,[11] found statistically significant higher rates of self-reported respiratory and constitutional conditions among the adult population living within a 1/4 mile radius of the site than it found among residents living between 3/4 of a mile and one mile of the site. Elevated complaints included (1) wheezing and/or tightness in chest, (2) cough, (3) persistent colds, (4) chest pains, (5) shortness of breath, (6) bowel disorders, (7) fatigue and tiredness, (8) headache, and (9) easy bruising and/or bleeding. For six of these (1,4,5,7,8,& 9) prevalence among the exposed group increased with proximity to the site. A statistically significant higher prevalence of sore throats and bronchitis among children in the exposed group was also reported.

Satin et al[9] compared the prevalence of self-reported symptoms in a population exposed to acid petroleum wastes in Fullerton, California, with a local control population. This study, concluded in 1981, found that 18 of the 25 adult symptoms and 18 of the 27 pediatric symptoms considered were statistically significantly higher in the exposed population.

Many of the symptoms, which included eye and nasal irritation, nausea, sore throats, coughing, headaches, fatigue and tiredness, loss of appetite, and sinus congestion, increased markedly with intensity of exposure.

Such surveys have caused concern within the scientific community regarding the interpretation of both positive and negative findings.[12,13] Some investigators have argued that epidemiologic surveys cannot help define etiologic associations in relation to liquid waste disposal unless certain preconditions are met. These have been summarized separately by Landrigan[12] and Heath,[13] and are paraphrased below.

1. The nature and quantities of the major environmental emissions from the site should be known.

2. The probable routes of human exposure (transcutaneous, inhalation, or ingestion) should be defined.

3. Individual exposure estimates should be definable or biologic assessments of absorption conducted.

4. High risk subpopulations should be defined prior to study.

5. Specific and sensitive health outcome indicators should be utilized.

These conditions present the epidemiologist with a dilemma, since each depends upon the existence of excellent quality exposure information, best

collected prospectively, from landfill site records, air monitoring surveys, hydrogeological surveys, and soil analysis. Such information was not routinely collected at the Upper Ottawa Street landfill site or at any of the other liquid waste facilities from the post-war period which have come to public prominence in recent years.

In the absence of prospective data collection, concurrent analysis of the landfill contents, hydrogeological surveys, or scrutiny of the waste production records of companies using the landfill might help reconstruct exposures. Where sites were owned or operated for the use of specific companies or industries, this process might be successful in identifying specific substances with known toxicities, from which target health problem hypotheses could be generated.[7] However, when a site was used for multi-source dumping, indeterminate quantities of large numbers of chemicals will likely be identified. In such a case, specific causative hypotheses may be harder to generate[14] and the conditions for epidemiologic study identified by Landrigan[12] and Heath[13] may not be met.

Does this mean that health studies should not be carried out? Certainly not. Failure to meet these conditions does not reduce public concern regarding possible health effects, and the potential is great for a conflict between public perceptions and scientific needs. Levine[15] has documented the negative psychosocial impact among residents in reaction to traditional scientific behaviour from decision makers during the Love Canal crisis. Her observations pose a challenge to the epidemiologist investigating the potential health impact of a toxic waste disposal facility. Should the usual scientific standards of technical precision and cautious interpretation be strictly maintained or should a pragmatic approach be taken which seeks to provide the best documentation of health status possible under the constraints imposed by the situation? This investigation is based on the latter philosophy.

In the absence of high quality exposure information, investigators have used duration of residence and proximity to exposure source in place of individual estimates of chemical-specific exposure[9], and have used non-specific

(environmental) health indicators as outcome variables.[7,8,9,14] While these compromises may reduce the validity of an epidemiologic survey, they do not pose problems which are insurmountable. Selection of the most appropriate non-specific health indicators and adoption of strategies to avoid subject recall biases will help overcome validity problems.

Suggestions for appropriate non-specific indicators include both clinical and pathologic outcomes. Among the clinical outcomes, reproductive and developmental effects,[8,14] cancer,[14] respiratory and skin problems,[7,8,9] irritant symptoms,[7,8,9] and neuropsychological deficits[8,16] have received the most attention. Each group of outcomes has both advantages and disadvantages. In general, those health problems which are long-term, most serious, or potentially most clinically distinct may be too rare to achieve acceptable study power, since populations exposed to landfills, unlike occupational cohorts, often include few long-term or high-dose individuals.[12] Studies which confine themselves to such outcomes will therefore be uninterpretable if they give negative results. Studies confined to common respiratory, irritant, dermal, or neuropsychological problems will tend to lack credibility if they are positive, since recall biases, the health effects of lifestyles and occupation, and problems with the reliability and biologic relevance of symptom histories will threaten their overall validity.

Surveying markers of environmental pathology has been raised as a theoretical solution to the difficulties posed by clinical markers. Suggested markers may be grouped by pathologic process and organ-system (measures of mutagenesis,[14] neurotoxicity[16] and hepatotoxicity[17]), or by exposure (for instance, metal toxicity[18,19]). Could such markers solve the study power problem related to chronic disease outcomes and also the credibility problem related to symptom histories? If markers of exposure-specific, chronic disease were able to identify a larger at-risk subpopulation than would be possible using the disease itself, the problem of low study power would be mitigated. (For instance, B-2-

microglobulinuria might identify the at-risk population for cadmium nephropathy.[18]) With respect to symptom histories, sensitive markers might be able to distinguish self-reports attributable to the exposures of interest from those related to other factors.

The difficulties of using pathological markers may be illustrated by the recent study of cytogenetic findings from Love Canal.[20] In that case, the utilization of sister chromatid exchange failed to provide a credible assessment of risk because the positive and negative predictive value of the test were not known and the clinical implications of the test result itself were not well understood.

The use of pathological markers was not initially considered in the Upper Ottawa Street Landfill Site Study because no exposure related hypotheses were sufficiently well defined to make their use feasible. Effort was made to maximize the validity of the health questionnaire survey by a series of strategies which are detailed in the materials and methods section of this report. This approach corresponds to the strategy recommended by an Executive Scientific Panel convened by the Universities Associated for Research and Education in Pathology, in their report Health Aspects of the Disposal of Waste Chemicals:[21]

> "In contrast to the methods used by physicians to develop a diagnosis of disease in individuals, the initial detection of a disease in populations near a chemical disposal site is often best accomplished by other means. Where the history and physical examination is often not practical for large groups of individuals, pertinent information can be gathered more efficiently and effectively with a well constructed questionnaire. Laboratory testing as an initial screening procedure is usually not beneficial. Preliminary epidemiologic studies frequently find only non-specific complaints such as ambient odours, headaches, dizziness, fatigue, loss of libido, or menstrual irregularities. In such instances, careful detailed clinical and laboratory studies are seldom justified".

IV MATERIALS AND METHODS

(a) Landfill Area Residents

Six groups of "exposed" households were selected for health survey interviews:

1. those living 250 to 500 metres from the edge of the dumpface at the time of interview (see Figure 2), who had been resident there for 3 or more years between 1976-80.

2. those living 250 to 500 metres from the edge of the dumpface at the time of interview, who had been resident there for less than 3 years between 1976-80.

3. those living 500$^+$ to 750 metres from the edge of the dumpface at the time of interview (see Figure 2), who had been resident there for 3 or more years between 1976-80.

4. those living 500$^+$ to 750 metres from the edge of the dumpface, at the time of interview, who had been resident there for less than 3 years between 1976-80.

5. those living 250 to 750 metres from the edge of the dumpface, at the time of interview, but who had not been resident there between 1976-80.

6. those who lived 250 to 750 metres from the edge of the dumpface sometime between 1976-80, but who subsequently moved out of the area.

Table 3 summarizes these groups and others we did not sample in this study. The following sections explain the sampling strategy for exposed households:

(i) Window of exposure - Verbal reports by landfill workers suggested that disposal of industrial waste began in the mid-1960s. Available records suggested that 1976-1980 was the period of highest volume disposal of industrial waste at the landfill. During 1980, the site was closed to disposal, and was capped late in the year. Thus, residents of the area between 1976 and 1980 should have had the greatest potential for exposure to landfill site emissions. The window of exposure concept means that residence time prior to 1976 was counted as exposed time for those who moved into the area before then, but those who lived in the area and moved out before 1976 were excluded from the study. Those who fell within the window of exposure were further divided into those with less than 3 years exposure during 1976-80, and those with 3 or more years. This distinction made it possible to plan a 3-point analysis of health problems by duration of exposure: long-term, short-term, and controls.

(ii) Distance of residence from landfill - The choice of a 750 metre cutoff, and bisection into two, 250 metre exposure areas (figure 2) were arbitrary decisions based on sample size considerations, ease of analysis, and cost. There were no data available documenting community exposure patterns during the period of peak disposal activity so there was no scientific basis for establishing a cutoff distance beyond which no exposure to landfill emissions had occurred. Bisection of the 250-750 metre zone into two bands made it possible to plan three-point analyses by level of exposure: those 250 to 500 metres from the dumpface, those 500^{+}-750 metres from the dumpface, and controls.

Preliminary estimates from tax assessment rolls suggested that there were approximately 784 households within 750 metres of the dumpface which met our window of exposure criteria (see Table 3, groups number 1000, 2000, 3000, and 4000.) Two hundred and eighty of these were within 500 metres of

Table 3: **Initial Classification of Households Adjacent to the Landfill Site**

Current Residence	Distance from Landfill	Years of Exposure from 1976 to 1980	Number of Households	Group No.	Eligibility
Still There (as of May, 1983)	250-500 metres	3 years	156	1000	Yes
		0 x 3 years	124	2000	Yes
		no exposure at that time	149	7000	Yes
	500-750 metres	3 years	258	3000	Yes
		0 x 3 years	246	4000	Yes
		no exposure at that time	176	7000	Yes
Moved	250-500 metres	3 years	87	8000	Yes
		0 x 3 years	248	8000	Yes
		no exposure at that time	28	—	No
	500-750 metres	3 years	74	8000	Yes
		0 x 3 years	382	8000	*
		no exposure at that time	40	—	No

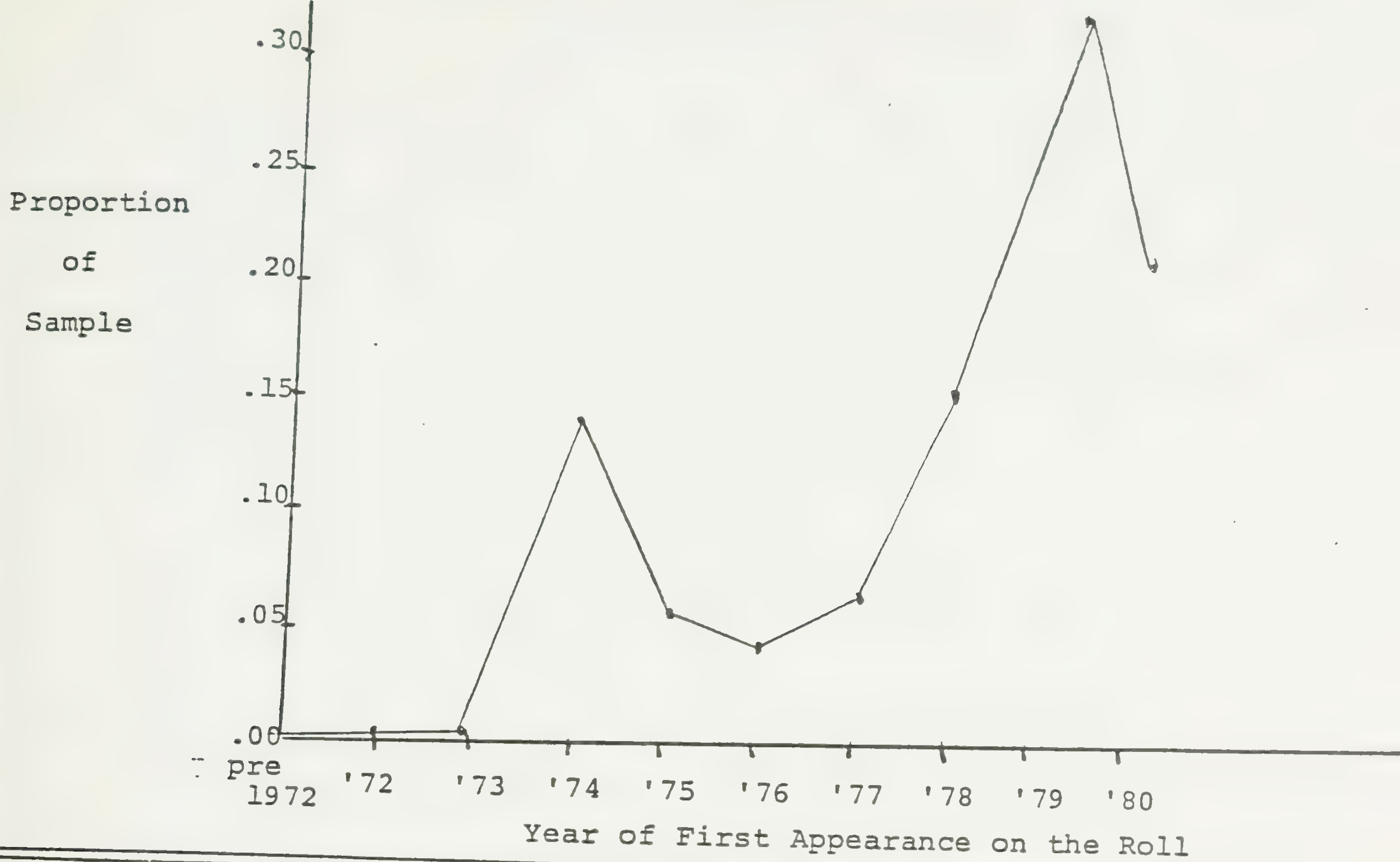
* Randomly-selected 50% of subgroup used in pre-test, 50% used in main study.

the dumpface and 504 households were between 500+ and 750 metres. Sample size considerations were dominated by detecting the rarest important outcome: a risk of birth defects, if one existed. Calculations showed that achieving 90% power to detect a two-to-threefold increase in a condition with a one percent prevalence in controls (i.e., all clinically significant birth defects) would require 950 to 3000 childbirths among both exposed and controls groups. A household interview sample large enough to guarantee this many childbirths could not be found adjacent to the landfill. Ultimately, a sample of 614 houses were identified in the 1000 to 4000 series (see Table 4). Assuming an 80% response rate and 1.3 childbirths per household following first residence at the landfill, this sample size would have allowed 80% power to detect a relative risk of 3.0 for "all birth defects".

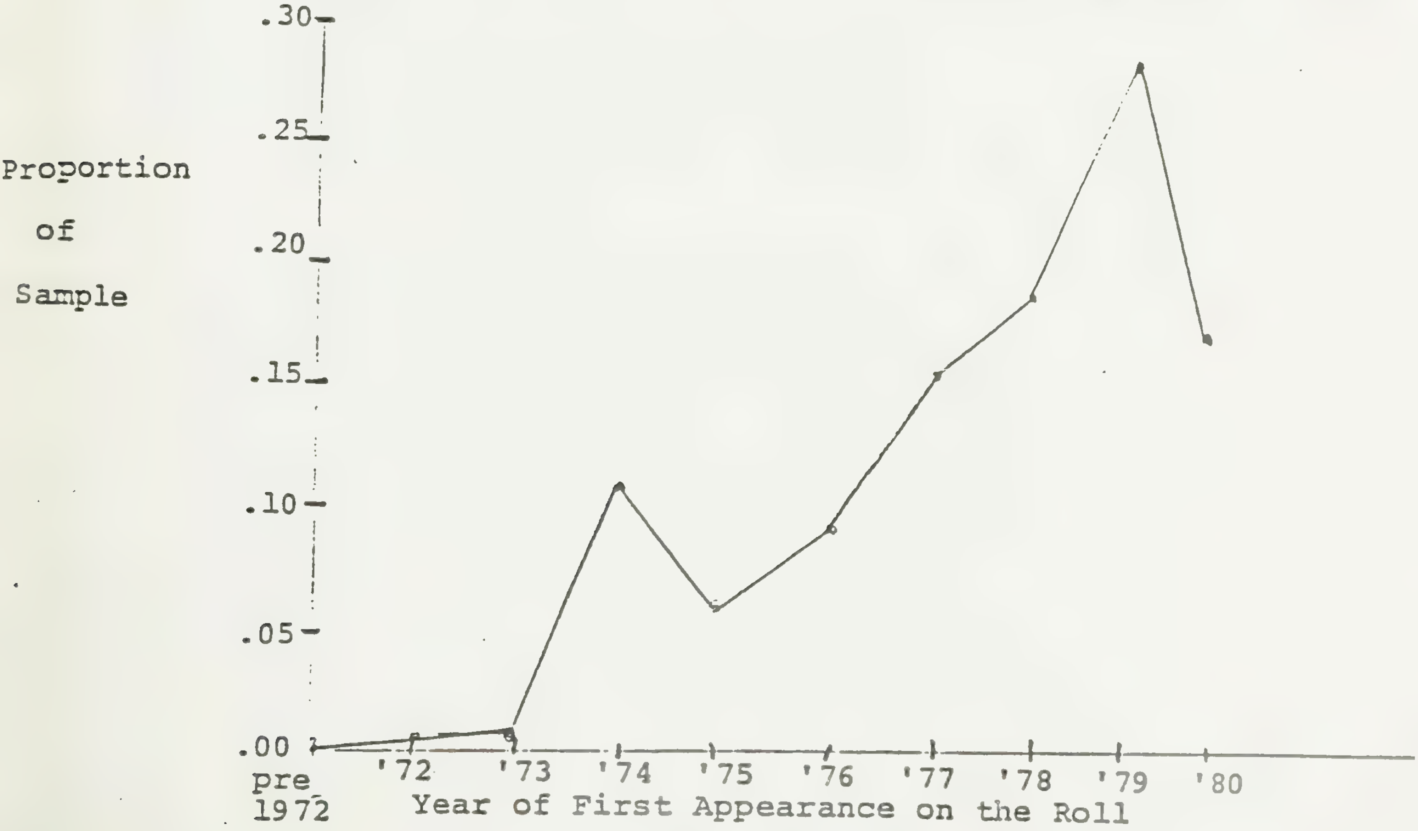
(iii) Time of first exposure - Figure 3 shows the years of first appearance on the tax assessment role for those living within 750 metres of the dumpface between 1976 and 1980. Few households were listed before 1973. Since the year of first appearance on the roll usually follows the year of first residence by one year, it was assumed that virtually none of the eligible households had been established near the landfill before 1972. Therefore, 1972 was defined as the year of first exposure for the purposes of questionnaire design and control selection.

(iv) Subgroup identification and follow-up - Tax assessment rolls were consulted for 1983, 1980 and 1978 in order to create the subgroups found in Table 3. The following table shows how the group assignments corresponded to the record of households from the assessment rolls.

Figure 3(a): Year of First Tax Assessment for Households Appearing on the Roll between 1976-1980, and Still Present on the 1983 Roll.



(b) Year of First Tax Assessment for Households Appearing on the Roll between 1976-1980, but NOT Appearing on the 1983 Roll.



	Tax Assessment Roll		
Groups	1978	1980	1983
1000 and 3000 series	present	present	present
2000 and 4000 series	absent	present	present
7000 series	absent	absent	present
8000 series	present	present	absent
8000 series	present	absent	absent
8000 series	absent	present	absent

The guidelines used to make group assignments were as follows, based on the observation that the assessment rolls tended to reflect the previous year's residence:

(a) If present on the May, 1983 tax roll, the household was included as still resident near the landfill for the purposes of planning.

(b) If present on the 1983 roll, but absent from the 1980 and 1978 rolls, it was assumed that the family moved in no earlier than mid-1980 and was therefore minimally exposed before the site was closed and capped.

(c) If present on the 1983 and 1980 rolls, but absent from the 1978 roll, it was assumed that maximum exposure would be less than 3 years (latter part of 1978, all of 1979, 1980 before the site was capped).

(d) If present on all three rolls, it was assumed that exposure included part of 1977, all of 1978 and 1979, and 1980 before the site was capped.

Table 4 shows how the initial household assignments evolved over time. Discrepancies between the initial tax assessment estimates and the number of households available for assignment were small for the 1000 to 4000 series. These mostly represented double reporting of families on the rolls. Substantially fewer households were available for assignment in the 7000 series than estimated from tax assessments (325 estimated, 219 assigned).

Table 4: Evolution of Eligible Households for Study

Sampling Group	Initial Estimates from Tax Assessments	Households Available for Assignment	Households Lost During Interviewer Contact		Households Eligible after Interviewer Contact
			Ineligible	Moved	
Landfill Residents					
1000 series	156	152	0	22	130
2000 series	124	117	6	21	90
3000 series	258	256	3	35	218
4000 series	246	248	11	61	176
7000 series	325	219	8	49	162
8000 series	600	435*	39	48	348
Controls					
5000 series		195	1	24	170
6000 series		526	4	56	466

* Includes 32 households originally assigned as 1000 through 4000 series, who were found at a new address outside the landfill area.

The initial estimates had included many landowners who had not yet moved into the area or built there. This was discovered when phone numbers were sought for the households. Approximately two-thirds of the original 600 non-pretest households in the 8000 series (movers) were found within Hamilton and surrounding municipalities through drivers license records and local telephone directories.

(b) Controls

Control selection was based on the objective of achieving comparability in family size, age distribution, and socioeconomic status, since these factors would likely correlate closely with occupational and personal health risk factors which could confound the outcome of the study. Identification of an acceptable control community was hampered by three factors.

1. Since the Upper Ottawa Street Landfill Site area was developed during the mid-1970s, it was necessary to restrict the search for controls to other newly developed communities.

2. Timing did not permit us to conduct a census of the Landfill Site area or any potential control areas.

3. The Landfill Site area was spread out over four census tracts and eight Hamilton Planning Department Neighbourhoods. (Table 5). However, the proportion of population of each census tract within the study area ranged from 20 to 75 percent, while for planning neighbourhoods it was 0.5 to 34.0 percent. Thus, routinely collected data related to family size, occupation, and income were unhelpful in identifying a control community.

Table 5: Hamilton Planning Department Neighbourhoods Adjacent to the Landfill

Name	Census Tract 1981	Approximate Percent of Census Tract Households Eligible for Study	Percent of Study Sample from Each Planning Neighbourhood*
Quinndale	001.02	40%	34.0%
Templemead	001.02		9.2%
Rymal	001.01	75%	1.8%
North Hannon	001.01		0.5%
Albion Falls	001.01		8.4%
Trenholme	001.01		10.4%
Lisgar	005.03	30%	19.7%
Berrisfield	005.02	20%	16.0%

* Households within 750 meters of the edge of the dump face on the 1983 Tax Assessment

As an alternative, information on house size, type, building dates, and resale value were used as surrogates for family size, age, and socioeconomic status. Information provided by the Hamilton Planning Department helped to limit the search to neighbourhoods on the "Hamilton Mountain", which were the only other communities constructed at a similar time. These communities were situated on the Niagara Escarpment within five miles west of the Landfill Site (see figure 1). Therefore, they were in the same region for air pollution migrating south from Hamilton and north from the industrial belt in the U.S. northeast. Comparability of house size and type was based on the inspection of Planning Department and Real Estate Board records. The "Gilkson" neighbourhood and part of the contiguous "Fessenden" neighbourhood turned out to be the closest community match within the City of Hamilton. A visual inspection of the Fessenden/Gilkson area revealed a mixture of town houses and single detached dwellings similar to the landfill area, but also two high-rise apartment blocks. These were excluded from the control group. Resale values of houses within the two areas for August, 1983 were available. Thirty-three houses in the Landfill area had sold for an average of $75,840 (standard deviation $12,600). The range was $54,500 to $99,900. In the control community, 18 houses sold for an average of $74,570 (standard deviation $18,370). The range was $48,500 to $104,900. These observations, and the absence of any other suitable choice of controls within the City of Hamilton, led us to adopt the Fessenden/Gilkson neighbourhood.

Table 4 shows control households from tax assessment rolls divided into two subgroups: the 5000 series and the 6000 series. The 5000 series are those who lived in the control area for less than three years during 1976-1980. Their duration of residence is comparable to landfill residents in the 2000 and 4000 series. The 6000 series are those who lived in the control area for three or more years between 1976-1980. Both 5000 and 6000 series were current residents at time of interview. Migrators (analogous to the 8000 series) were not sampled from the control community because the assessment rolls revealed a very low rate of out-migration. Similarly, there were too few control area residents who moved in after the 1980 tax assessment rolls were compiled, to form a group comparable to the 7000 series.

The ratio of 5000 to 6000 series households (1 to 2.7) was lower than the ratio of 2000 plus 4000 series to 1000 plus 3000 series households. (1 to 1.1). Therefore, it was clear from the outset that the control community had a higher proportion of long-term residents and was less migratory than the landfill site community.

(c) Questionnaire Design

In order to fulfill the objectives of the study (see pages 1-2), the questionnaire had to provide information about the health of all members of each study household. Accordingly, the questionnaire was designed for administration to the female head of household who would report on behalf of the whole family. Five principal inputs were used in the initial design and content of the questionnaire:

1. the workers' study questionnaire - this questionnaire had proven to be clear, easy to administer, and comprehensive. It was used as a base upon which to build. Feedback from the interviewers was available to help revise it as appropriate. One important feature of the workers' study questionnaire was its use of multiple descriptions of similar health problems in separate response categories, with the instruction to the respondent to pick the best response available. This inclusive approach allowed the workers to find rubrics that appealed to their own lay terminology for specific health conditions. The trade-off was that some rubrics used in the questionnaire lacked medical credibility. A similar trade-off was used in the residents' study, most notably in the dermal and neurological sections. This is reflected in some of the "hypotheses" identified in Table 2.

2. preliminary results of the workers' study - preliminary analyses suggested that specific respiratory, dermal and neurological conditions might ultimately emerge as main hypotheses from the workers' study. The corresponding sections in the residents' questionnaire were strengthened. Questions were borrowed from the respiratory standardization questionnaire to supplement the respiratory questions; items regarding body distribution and qualifying phrases regarding frequency and severity of symptoms were added to the dermal section. Qualifying phrases were similarly added to the neurological sections.

3. the original residents' survey - the original residents' survey was re-examined to ensure that all relevant areas were covered.

4. Canada Health Survey[22] - the format for recording multiple household members' responses in consecutive columns was borrowed from the Canada Health Survey and was also used for recording information about multiple pregnancies for appropriate adult female respondents.

5. the necessity for including information on maternal and child health-sections on pregnancy history, maternal risk factors, and outcome were developed de novo for the residents' study. No validated questionnaires were available, so items were based on the investigators' knowledge of the epidemiologic and toxicologic literature regarding known and potential risk factors; and pregnancy outcomes potentially sensitive to environmental exposures. The list of congenital anomalies was adopted from that used by Frank and Corey in "A Report on Congenital Anomalies in Toronto (1979-1982)".[23] Questions on child development were modified from the Child Health Questionnaire of the Ontario Child Health Study.[24]

The questionnaire ultimately included the following items:

(a) identification of all current (or temporarily-absent) household members

(b) basic details about deceased household members and those who had moved away before the date of interview.

(c) family and individual residence history within the landfill site or control area.

(d) presence of long-term health problems in each family member (adapted from the Canada Health Survey questions regarding current presence of chronic health problems).

(e) each family member's smoking and drinking history.

(f) activities on lands and recreation areas adjacent to the landfill.

(g) history of acute and chronic health problems from 1972 until the date of interview (including items not thought to be related to environmental exposures).

(h) developmental history for those under the age of 16 at time of interview.

(i) pregnancy history for all female respondents who had a pregnancy since 1968.

(j) history of school attendance and work within 750 metres of the landfill.

(k) history of work in dusty jobs and jobs with chemical fumes.

(l) socioeconomic status (ethnic orgin, language, income, education, home ownership).

(m) consent to abstract physician and hospital records.

Pre-testing of the personal interview questionnaire was conducted on a sample of former residents who had moved between 500 and 750 metres from the landfill for less than three years from 1976 to 1980. These individuals were excluded from the tabulation of "8000 series" residents found in Table 4. Thirty-three household interviews were completed, relating to 135 individuals. The interviews averaged one hour and forty minutes. The longest took three hours to complete and the shortest took only thirty-five minutes. Nonetheless, feedback from the interviews demonstrated that the

questionnaire was too long for many of the respondents to maintain concentration and co-operation. Details of work history, alcohol intake, child development, and reproductive history were reduced. In particular, questions from the Respiratory Standardization Questionnaire were found lengthy, annoying, and redundant, and so, many were deleted.

A mail questionnaire was also pretested concurrently with the personal interview questionnaire. This strategy was a compromise between affordability on the one hand, and the need to increase study power and assess migrator bias on the other. Pre-testing demonstrated that information gained from the mail questionnaire was not comparable to that obtained on the personal interview, and so could not be used to assess migrator bias or to increase study power with respect to uncommon health problems. Also the response rate among the pre-test sample was very low. Refusals and untraceable addresses accounted for more than 50% of the pre-test interview sample. As a result of these difficulties the mail questionnaire was abandoned and personal interviews were conducted on all eligible subgroups as outlined in Table 3.

(d) Questionnaire Administration

The contract for interview administration was awarded to Hamilton Opinion Research Centre Limited (HORC) through a competitive bidding process. The pre-test and execution of the questionnaire and medical chart abstraction were managed by the principal contractor (Mr. Nick Sidoruk of HORC) in co-operation with the Upper Ottawa Street Landfill Site Study's epidemiology and toxicology consultants. Interviews were conducted in-home by trained interviewers experienced in studies of a sensitive nature. In-home interviews were a logistical necessity because of the need for access to the female head of household (who was frequently a homemaker) for an hour or

more. Publicity surrounding the landfill site and the study precluded the possibility of blinding exposed respondents to the purpose of the interview. However, an attempt was made to conceal the principal objectives of the study from the controls. The letter of introduction said the purpose of the interview was "to study the health of persons who live at various distances from the Upper Ottawa Street Landfill Site". Because the control community was less than five miles from the landfill, we thought it possible that controls might not identify themselves as "unexposed". If this were so, recall biases might be reduced, while at the same time, response rates might be enhanced.

Interviewers were blind to the hypotheses being tested and were unaware of which questionnaire items were distractors. Indeed, formal declaration of the hypotheses did not occur until after the field work was complete, but before the data was analyzed. Interviewers were each assigned a mixture of respondents from different subgroups. An informal survey of interviewers after the field work was completed revealed that no distinct impressions or theories of cause and effect had emerged among them.

Multiple call-backs were used in all situations where initial interview contact met with refusal or no answer. All initial refusals, multiple delays, or failures to keep an interview appointment were logged by the interviewers and screened by the interview contractor for reassignment and recontact. A member of the consultant team conducted a second screening of refusals which the interview contractor felt did not warrant recontacting. Twenty-four percent of the refusers recontacted as a result of the first screen agreed to be interviewed, as did 12 percent of the second screen. In retrospect, only harsh refusals were accepted on first contact, and interviewer logs reveal multiple contacts for virtually all refusers.

A team leader was identified among the interviewers who checked all in-coming questionnaires for completeness and internal consistency. Callbacks were conducted when such problems were identified.

When a female head of household was unavailable, the interviewers were given a hierarchy of alternate individuals to solicit in order. Where a family had split up, the order of priority for interview went as follows:

- if one part of the family had remained in the study area, it was interviewed and the rest was excluded.

- if both parts of the family remained in the area, both were interviewed separately.

- if both parts of the family had moved ("exposed" families only), interview was sought with the portion including the female head of household only.

When households were not found at the assigned address, the interview team returned the family information to the consultant team, who attempted to find the family through drivers' license records, local contacts, and leads picked up by the interviewers. Usually, this resulted in a household in the 1000 to 4000 series being re-assigned to the 8000 series. Movers were tracked down in Hamilton-Wentworth county and parts of the adjacent counties within a radius of approximately 25 miles from the site.

(e) Data Analysis

Table 6 summarizes the exposure status of the eight subgroups included in the study and lists the various short titles used to describe them throughout this report. Most important, the right-hand column identifies the subgroups included in each category of analysis. The overall analytic strategy was to assess the strength of association. consistency with the workers' study, and gradient of response by duration of exposure through comparisons between current landfill residents who were present between 1976 and 1980, and controls. Analyses involving the other subgroups (7000 and 8000 series) were designed to indirectly assess biases in the main analysis

Table 6: Identification Key for Sampled Households

Group ID	Exposure Status	Short descriptions of Groups Found on the Tables	
1000 (1)	3 yrs. residence within 500 metres of the land fill, 1976-80 and still there	"long-term" residents	"exposed" or "non-movers"
2000 (2)	less than 3 yrs. residence within 500 metres of the landfill, 1976-80, and still there	"short-term" residents	
3000 (3)	3 yrs. residence 500-750 metres from the landfill 1976-80, and still there	"long-term" residents	
4000 (4)	less than 3 yrs. residence 500-750 metres from the landfill, 1976-80, still there	"short-term" residents	
5000 (5)	less than 3 yrs. residence in the control area, 1976-80 and still there	"short-term" controls	"controls"
6000 (6)	3 yrs. residence in the control area, 1976-80, still there	"long-term" controls	
7000 (7)	moved into landfill area after 1980 , still there	"recent" residents	
8000 (8)	lived within 750 metres of the landfill sometime between 1976-80,and moved away	"movers"	

Groups Included in Specific Analyses

(a) Main Analysis
1-4 vs 5-6

(b) Gradient Analyses

i. overall: 1,2 vs 3,4 vs 5,6
ii. "long-term": 1 vs 3 vs 6
iii. "short-term": 2vs 4 vs 5

(c) Migrator Bias
i. 8 vs 1-4
ii. 8 vs 5-6

(d) Does the landfill area attract less healthy people?
7 vs 5-6

(e) Hypothesis generating
1-4 vs 5-6

(f) Conditions not expected to be related to exposure
1-4 vs 5-6

(g) Medical chart abstraction - recall bias
1-4 vs 5-6

which might have resulted from the high out-migration rate from the landfill area and from the possibility that the health of those choosing to live adjacent to a waste disposal facility might have systematic health status differences from other people of similar socioeconomic status not living in the area. Other analyses were confined to the main study groups. These included hypothesis-generating analyses; analyses checking the specificity of associations between landfill exposure and the main health problems (through analyzing conditions not expected to be related to exposure); as well as medical chart abstraction for recall bias. In all, five diagnostic tests of causation (strength of association, gradient, temporality, specificity, and consistency) and three sources of bias (recall, migrator, and "risk-taker" bias) could be addressed through this analytic strategy.

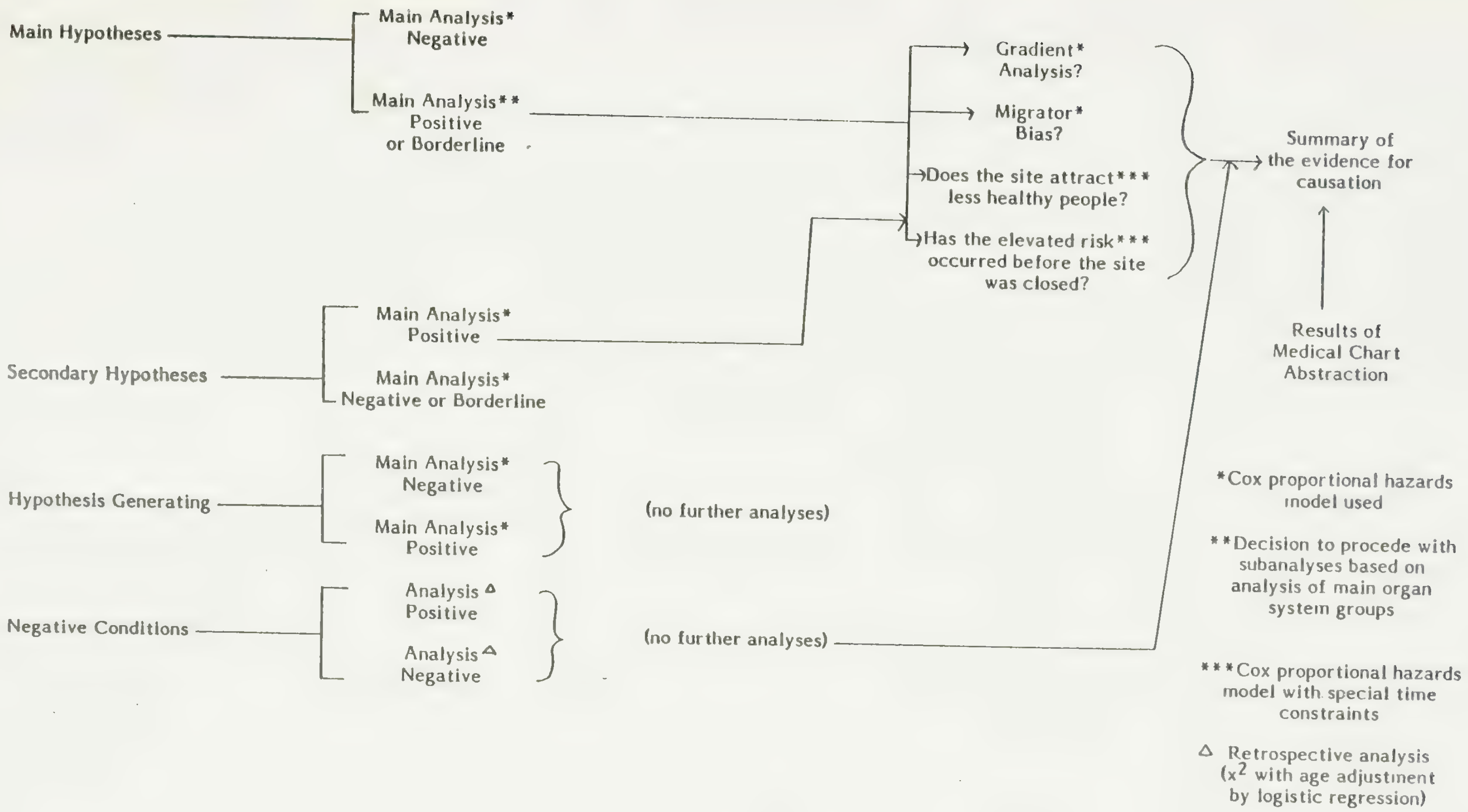
Table 7 shows the flow of events for analysis of four groups of health conditions: main hypotheses, secondary hypotheses, conditions suitable for hypothesis-generating and those thought to be unrelated to environmental exposure. The conditions identified as main hypotheses have been identified in Table 2 while the secondary hypotheses have been listed on pages 10 and 14 of the Background section. Other conditions included in the subsidiary analyses will be identified in the Results section of this report.

Cox proportional hazards models[25] were employed in each main analysis, and were developed in the following way:

1. The data set was divided into those who were 16 years of age or older ('adults') and those who were less than age 16 ('children') at the time when they first moved into the landfill site community. The two groups were analyzed separately.

2. All major sociodemographic variables and other confounders in the data set were compared between exposed individuals or households, and controls.

Table 7: **Flow-of-Events for Data Analysis**



*Cox proportional hazards model used

**Decision to procede with subanalyses based on analysis of main organ system groups

***Cox proportional hazards model with special time constraints

△ Retrospective analysis (x^2 with age adjustment by logistic regression)

3. The Cox model takes into account the fact that events occur at different times after initial exposure. That is, a person contributes person-years at risk only from the time of first exposure until the time he/she experiences the health condition being analyzed. In assessing the main effect of exposure on the rates of various health conditions, it can also control for the influence of possible confounding variables (e.g. age). All biologically plausible confounders were available for inclusion in Cox proportional hazards models for each health condition. They were entered stepwise, with a "p to enter" of 0.10 and a "p to remove" of 0.15.

Person years at risk were calculated from the year of first residence at the landfill site or control community. Only current residents of the landfill (1000 to 4000 series) or controls (5000 and 6000 series) were included. For those who lived in either community before 1971, 1972 was taken as the first year at risk. Person years were counted until the year of interview (1984). Only first incident events occurring after first residence at the landfill site or control community were included in the analysis. When biologically related groups of health conditions were analyzed, only the first eligible incident event within the group was counted. Those reporting first events prior to exposure did not contribute person-years to the analysis. Smoking history, work history and other risk factors with a cumulative impact were considered for inclusion even if they occurred before first residence in the community of interest.

The relative risk was derived from the exponent of the hazard function in the Cox model, which is an estimate of the instantaneous hazard rate. The Cox model assumes that the instantaneous hazard ratio is constant over time. Main analyses of the main hypotheses were

declared positive if the p(relative risk) was ≤ 0.01. The p(relative risk) was based on the Z score from:

$$\frac{\text{partial coefficient (group/confounders)}}{\text{standard error of coefficient}}$$

Adopting an alpha level of 0.01 simultaneously adjusted for multiple testing of five organ-system groups and for four-to-five conditions within each organ-system group among the main hypotheses. The secondary hypotheses were declared positive if $p < \frac{0\ .05}{n}$ where "n" was the number of secondary hypotheses separately among adults and children. This approach was appropriate for multiple testing by organ-system, since the symptoms may be thought to be independent between organ-system. However, it is conservative within organ-system, since the assumption of independence of symptoms is likely to be violated.

4. Subanalyses: Among the main hypotheses, subanalyses were conducted only on organ-system groups. Among the secondary hypotheses, subanaylses were conducted only on these where the main comparison was "positive". All subanalyses were Cox proportional hazards models, with the same confounding variables as in the respective main analyses. Specific approaches were as follows:

    (a) Gradient Analysis - The main study groups were divided into those who lived within 500 metres of the dumpface (1000 and 2000 series), 500 to 750 metres of the dumpface (3000 and 4000 series), and controls (5000 and 6000 series) and analyzed for a linear trend in incidence rate with proximity to the site. Separate analyses were then conducted on the long-term residents (1000, 3000 and 6000 series) and short-term residents (2000, 4000, and 5000 series) to see whether or not the principal contribution to the linear trend came from the long-term residents. Evidence of a linear

trend, stronger among long-term than short-term residents, would support causation, regardless of whether or not the conditions resulted from acute or chronic exposure. Analyses of subgroups organized by duration of exposure only (long-term 1000 and 3000 series; short term 2000 and 4000 series; controls) were not included because it was thought that non-current analyses would be invalid without direct evidence that levels of exposure to landfill site emissions were roughly constant throughout the exposure window (1976-1980).

(b) Did the elevated risk develop before the landfill site was closed? - The main analyses were recalculated excluding all health conditions reported after 1980. This allowed the investigators to find out whether or not a risk developed during the period of most active liquid waste disposal at the landfill. Also, if a risk diminished after the site was closed, removing 1981 to 1984 from the analysis should have resulted in an increased relative risk in the "1980 and before" analysis. This latter consideration was invoked when the results of the main analysis were of borderline statistical significance ($0.01<p<0.05$) among the main hypotheses.

(c) Migrator Bias: Two sets of analyses were carried out to assess the effect of out-migration of landfill site area residents. The first compared the migrators (8000 series) to the current residents who had been in the landfill area when liquid waste disposal was occurring (1000 to 4000 series). This analysis was done three ways: including all health events up to the time of inverview; and excluding events occurring after 1980; and excluding all events before 1981. The second approach compared the migrators to the controls (5000 and 6000 series) and was carried out on all health events up to the time of interview. Evidence of migrator bias may be divided into two forms: that which would tend to

artificially increase the apparent risk associated with exposure to the landfill and that which would tend to artificially decrease the apparent risk. Evidence supporting the former would be present if the "migrators" had lower rates of the conditions of interest than did the exposed "non-migrators", and if they were more like the unexposed controls in health status than they were like the "non-migrators". Evidence supporting the latter would be present if the "migrators" had higher rates of the conditions of interest than did the exposed "non-migrators". Evidence that the migrators were more healthy than the non-migrators would tend to weaken "positive" results in the main analysis. Evidence that the migrators were less healthy would tend to strengthen positive results.

(d) Has the landfill site area attracted less healthy people? -This question was addressed by comparing the health of those who moved into the landfill site area after 1980 (7000 series) with the controls. Two comparisons were made. The first involved all health problems reported since 1972 by each group, irrespective of where they lived. The second involved only health problems which were reported after first residence in the qualifying household, and occurred between the beginning of 1981 and the time of interview. The rational was that, if the landfill site are attracted less healthy people, this sould be reflected in their reporting higher rates of health problems from 1972 to the present. Increased rates of reported health problems from 1981 to the present might represent either landfill site effects or the underlying unhealthiness of those attracted to the area. The following table gives guidelines for interpreting these analyses:

	Comparison		
	(1972-1984) Recent Residents Controls	(1981-1984) Recent Residents Controls	Conclusion
1.	Relative Risk $>$ 1.0	Relative Risk $>$ 1.0	Landfill site attracts less healthy people
2.	Relative Risk $<$ 1.0	Relative Risk $>$ 1.0	Landfill does not attract less healthy people; ongoing exposure must be considered
3.	Relative Risk $>$ 1.0	Relative Risk $<$ 1.0	Inconclusive

Hypothesis-generating Analyses - A few adult and child health conditions were not included among the main or secondary hypotheses but nonetheless were of interest in the study of health effects related to landfill site exposure. These were analyzed using the proportional hazards approach, but were not included in any subanalyses.

Conditions Not Thought to be Related to Environmental Exposure - All health conditions on the questionnaire which were not included in the main hypotheses, secondary hypotheses, or hypothesis-generating groups were eligible for inclusion. All those conditions with 30 or more events in total among the main study groups (series 1000 to 4000, and series 5000 to 6000) were deemed to be analyzeable and were included. Ultimately, the analysis excluded health events which occurred before residence at the qualifying household. Thus, several analyses ended up with less than 30 events. This somewhat awkward approach was necessary to ensure that inclusions and exclusions were made blind to the relative distribution of health events between landfill site residents and controls. The overall purpose was to assess the specificity of the possible associations(s) between landfill site exposure and the main and secondary hypotheses. If many conditions (not thought to be related to environmental exposure) were also associated with landfill site exposure, the credibility of positive results would be reduced. Therefore, analysis of conditions not thought related to environmental exposure were interpreted collectively, not individually in relation to the overall objectives of the study. Table 7 gives details of the methods of analysis.

Reproductive Problems - A reproductive mini-questionnaire was included in the questionnaire to screen for evidence of adverse outcomes associated with residence adjacent to the landfill site. The pregnancy experience of all females in the study households was solicited from 1968 to the date of interview. Those pregnancies occurring after first residence in the qualifying household were included in the analysis. The main study groups (1000 to 4000 series and 5000 to 6000 series) were compared by risk factors using simple univariate techniques. Negative pregnancy outcomes considered in the analysis included low birth weight, still birth/spontaneous abortion, and the presence of any major or minor birth defects. These, too, were compared using simple univariate techniques as an initial screen. Multivariate analyses and clinical follow-up were contemplated if any positive results emerged from univariate analyses.

(f) Medical Chart Abstraction

In the Workers' Study which preceded this one, self-reported health conditions were evaluated for recall bias by abstraction of family practice medical records. Abstractors were not blinded to respondent self-reports so that they were free to interpret the available medical records. Nine possible relationships between the medical chart and questionnaire response were itemized by the study investigators. Two represented 'confirmation'; four represented 'possible confirmation'; and three represented 'non-confirmation'. After search of available medical records, the abstractors rated each self-report by this nine item scale. Analysis and interpretation was reduced to three groups: 'confirmed', 'possibly confirmed', and 'not confirmed'.

This approach had two basic flaws: abstractors were unblinded to respondent self-reports; and underreporting of health problems could not be reliably assessed. The former problem was mitigated by the fact that the abstractors were blinded to the 'exposed' or 'control' status of the respondents. The latter problem was insoluble because it was difficult to artificially determine boundary lines between possible confirmation of self-reported conditions and confirmation of unreported conditions for all 120 health problems found on the workers' study questionnaire. The approach taken to medical chart abstraction on the residents' study was designed to correct these problems.

The twin objectives of blinding abstractors to study subjects' reported complaints and of obtaining parallel data on respondent under- and over-reporting, were achieved by abstracting a limited number of health conditions. The process of selecting eligible conditions went as follows.

Adult and child conditions were grouped by organ-system or biologically-related cluster. For adults, this involved excluding two groups which were thought to be least relevant among a young population: cardiac and arthritic complaints.

The rest of the conditions were divided into nine groups. Six of these (respiratory, hematologic, renal, digestive, skin, and head and neck) corresponded directly to the groupings in the questionnaire. The remaining three (central nervous system, peripheral nervous system, and psychological) were subdivisions of the nerve and muscle condition group on the questionnaire. Two conditions were randomly sampled from each of these nine groups. The first condition selected was designated for abstraction, and the second served as an alternate. The alternate condition substituted for the designated condition in any of three situations:

1. If the projected number of abstractable events for the designated condition was less than 30, based on a tabulation done at the two-thirds completion point of the study, it was felt that too few events would be available for abstraction.

2. If more than 100 events were projected for a designated condition, the overall analysis of reporting bias would be unduly weighted by that condition, since we were restricted by budget to approximately 600 abstractions.

3. Some conditions (e.g. shortness of breath, or pain and cramps in legs and feet) were found to be unabstractable on pre-testing. This was usually because they were found as symptoms subsidiary to a variety of health problems which were not being abstracted. This made it very difficult to define a reliable boundary between possible confirmation and non-confirmation to serve as a guideline to the abstractors.

A similar process was conducted for child conditions. In this case, only five groups of conditions could be defined with sufficient numbers of events to warrant sampling (respiratory, dermal, head and neck, child development, and a miscellaneous category). Table 8 shows the final list of conditions which were abstracted.

Table 8: Conditions to be Abstracted

ADULT

#1	C004.	Pneumonia, including bronchopneumonia
#2	C025.	Nosebleeds (not from injury)
#3	C040.	Needing to get up more than once at night to urinate
#4	C057.	Loss of weight
#5	C067.	Recurrent or severe problems with unusual acne
#6	C076.	Prolonged, irritated, sore throat
#7	C081.	Ringing in the ears or tinnitus
#8	C090.	Constant fatigue, lethargy or drowsiness
#9	C097.	Numbness, tingling, prickling or loss of sensation on arms or hands

CHILD

#10	C006.	Asthma
#11	C044.	Food allergies
#12	C066.	Recurrent or severe problems with skin rashes or hives
#13	C078.	Red, itchy, watery, sore, dry or inflamed eyes
#14	C125.	Problems with normal child development in terms of physical growth or development

Medical chart abstraction was restricted to the main study groups (1000 to 4000 series; and 5000 to 6000 series). Individuals were included in medical chart abstraction if they had reported having one or more of the nine adult, or five child conditions since 1972 and had provided the name of a local physician whom they saw for these conditions. In addition, a sample of 60 subjects was randomly selected who had reported none of the conditions of interest. (40 adult, 20 child.) Individuals reporting a condition of interest were excluded if it began before 1972, if no physician were seen, or if the physician was unavailable for follow-up in the Hamilton area. The abstractors searched the records of all family physicians reported as the physician(s) seen for the conditions(s) of interest. For those 50 individuals who reported none of the conditions of interest, the records of the physician most often reported on other condition sheets were abstracted. Usually, one family physician predominated. But in five cases, two family physician records were abstracted. The abstractors searched medical records for all nine adult (or five child) conditions, blind to the reporting status of the study respondents. Thus, over-reporting was based on the proportion of reported conditions which were not confirmed and under-reporting was based on the proportion of unreported conditions which were confirmed or possibly confirmed.

The study investigators viewed the abstraction process as a method to assess recall bias, not to quantify the accuracy of reporting. Because abstraction was not exhaustive of all medical records, because physicians may not have recorded all symptoms, and because of the arbitrary nature of 'confirmation' and 'non-confirmation', the estimates of proportions of under- and over-reporting are only meaningful when compared between study groups. They have no meaning as estimates of absolute reporting accuracy. Moreover, estimates of over- and under-reporting cannot be combined in a single summary analysis, since this, too, would imply that the absolute values of the estimates were individually meaningful.

The flow of events for the abstraction study went as follows:

1. The study investigators developed overall guidelines for 'confirmation', 'possible confirmation', and 'non-confirmation' of the conditions. Five categories were created, and two exclusion categories were defined. (See Appendix Book.) In addition, specific examples of all seven categories were written for all 14 conditions to be abstracted.

2. The nurse abstractors went through a 'dry run' of two charts in a workshop session during which time the abstaction materials were discussed. They then pre-tested the instruments on a total of 21 family physician charts. These were derived from study groups (e.g. 8000 series) not included in the main abstraction study.

3. The materials were revised in the light of the abstractors' pre-test experience. A second workshop was held to familiarize the abstractors with the revised instruments.

4. Before re-entering the field to conduct the main abstraction study, a reliability workshop was held. All 10 abstractors concurrently reviewed six charts (four adults, two child) which were selected from the main study sample by special permission of the family physicians. No discussion was allowed during the workshop, so that each abstractor's work was her own. The data from this workshop was put in storage until the end of the study so that it could be used to assess the reliability of the study materials only, and not the performance of specific abstractors.

5. A total of 581 charts were assigned for 568 study respondents selected for abstraction. Abstractions were conducted in family physician offices, and the whole process took approximately six weeks to complete.

6. A second reliability workshop was conducted at the end of the abstraction study, using the same format and the same six charts. The time and mass of work carried on in the intervening six weeks made abstractor recall unlikely. The data from the workshops was used to calculate pre-test and post-test reliability of the tools for abstraction, and also to estimate intra-abstractor reliability.

V. RESULTS

1. Descriptive Statistics

(a) Response Rate

Table 9 gives household response rates by study group for the interview questionnaire. Response rates for the households currently adjacent to the landfill site ranged from 80.0 to 84.6 percent; while 75.3 percent of mover households and 67.8 percent of controls responded. The differences in response rate are readily explicable by the degree of self-interest each group of households would have had in the results. Unfortunately, the control group's response rate leaves open the possibility of a volunteer/non-respondent bias affecting the study results. The reasons most often given for refusal were "too busy" or "not interested". This was true for all groups. Refusals for reasons of ill-health were rare, accounting for only six of 109 refusals among the recent residents, and three of 86 among the movers. Nonetheless, it is possible that other refusals were related to health status in an unstated way.

(b) Sociodemographic Characteristics

Tables 10 and 11, and figures 4 and 5 describe household and individual sociodemographic characteristics for four study groups (exposed residents, controls, movers, and recent residents). Exposed and controls are compared using x^2 statistics.

Table 10 shows that the modal income for exposed, control, and mover households was \$30-39,999 in 1983. The modal income for recent resident households was \$20-29,999. Controls had a higher overall income distribution. Only 6.7 percent of controls households had incomes of less than \$20,000, while 35.2 percent were \$40,000 or more. Among exposed

Table 9: Questionnaire Completion Rates By Study Group

	1000	2000	3000	4000	5000	6000	7000	8000	TOTAL
Eligible Households (see Table 4)	130	90	218	176	170	466	162	348	1760
Refused	20	18	40	31	60	145	32	86	432
Completed	110	72	178	145	110	321	130	262	1328
Completion Rate	84.5%	80.0%	81.7%	82.4%	64.7%	68.9%	80.3%	75.3%	75.5%
	"Exposed" Group: 505 complete/ 614 eligible = 82.2%				Control Group: 431 complete/ 636 eligible = 67.8%		Recent Residents: 130 complete/ 162 eligible = 80.3%	Movers: 262 complete/ 348 eligible = 75.3%	

Table 10: **Comparability of Groups by Selected Household Characteristics**

	Characteristics	Categories	Distribution of Responses				(x^2) (Exposed vs Controls)	(p)
			Exposed	Controls	Movers	Recent		
1.	Total Family Income Before Taxes, 1983	(a) less than $10,000	16	1	6	6	26.36	<.001
		(b) 10-19,999	51	25	27	12		
		(c) 20-29,999	124	87	60	36		
		(d) 30-39,999	171	137	77	35		
		(e) 40,000 or more	111	136	73	34		
2.	Ownership of current home	owned	414	420	276	91	72.37	<.001
		rented	90	4	86	38		
3.	Family Size	Median	4	4	4	4	--	--
		(range)	(1-11)	(1-7)	(1-9)	(1-7)		
4.	Respondents' Degree of Co-operation (Interviewer Assessment)	(a) complete	464	380	241	109	1.41 *	.234
		(b) general co-operation (not fully open on all questions)	34	37	19	17		
		(c) substantial lack of co-operation	7	7	2	3		
5.	Level of Comprehension (Interviewer Assessment)	(a) full	431	393	246	109	12.39 **	<.001
		(b) generally good, not complete on some questions	65	25	13	16		
		(c) substantial difficulties	9	6	3	4		

* x_1^2 based on "complete co-operation" versus the rest.

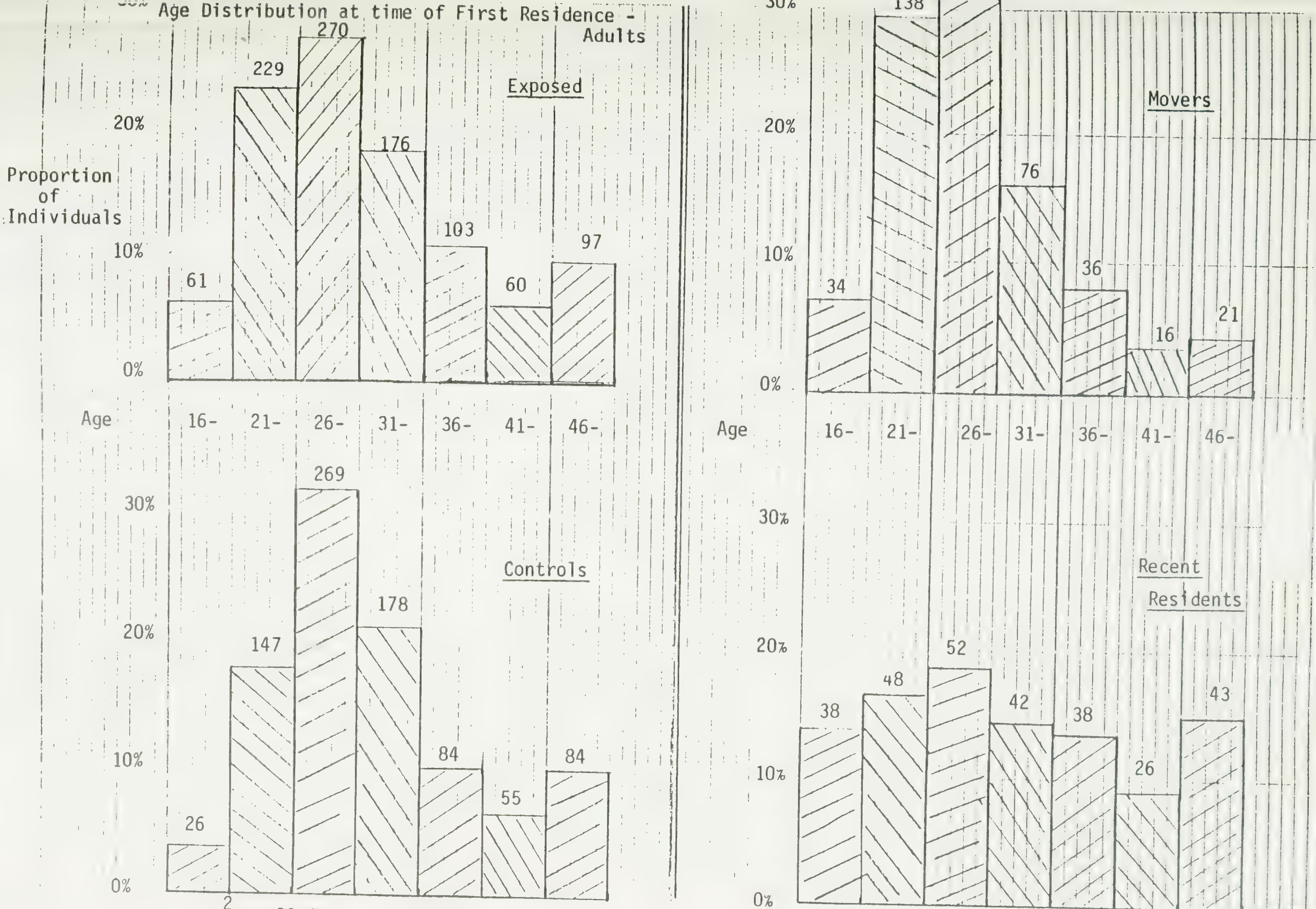
** x_1^2 based on "full" comprehension versus the rest.

Table 11: Comparability of Study Groups by Selected Sociodemographic Variables

Question	Categories	Distribution of Responses					$p(x^2)$
		Exposed	Controls	Movers	Recent	x^2	Exposed vs Controls
1. What is the highest level of schooling that ________ has completed? (those 25 years of age at time of interview only)	(a) grade 10 or less	282	157	119	83		
	(b) grade 11 to 13	399	350	193	85		
	(c) some post-secondary/university	78	59	31	12		
	(d) completed university/teacher's college	121	141	70	34	36.79	<.001
	(e) completed other post-secondary	89	121	47	22		
2. .... current occupation of those 16 years or older at time of first residence.	(a) student	11	12	9	21		
	(b) white collar	311	389	198	104		
	(c) blue collar	397	239	267	94	49.002**	<.001
	(d) housewife	244	169	81	54		
	(e) unemployed	17	11	9	6		
	(f) retired	15	21	4	8		
3. ..... ever worked for a year or more in a dusty job? (those 16 years or older at time of first residence)	yes	297	217	142	67	3.70	.055
	no	698	624	326	220		
4. .....ever worked for a year or more with chemical fumes or gases? (those 16 years or older at time of first residence)	yes	245	180	98	55	2.66	.103
	no	750	661	370	232		
5. Country of birth (all subjects)	Canada	1422	1170	721	353	1.15	.184
	Other	555	421	199	109		
6. Language first learned (all subjects)	English	1531	1286	808	356	4.54	.033
	Other	434	305	112	106		

** based on combining "Student", "Unemployed" and "Retired" categories.

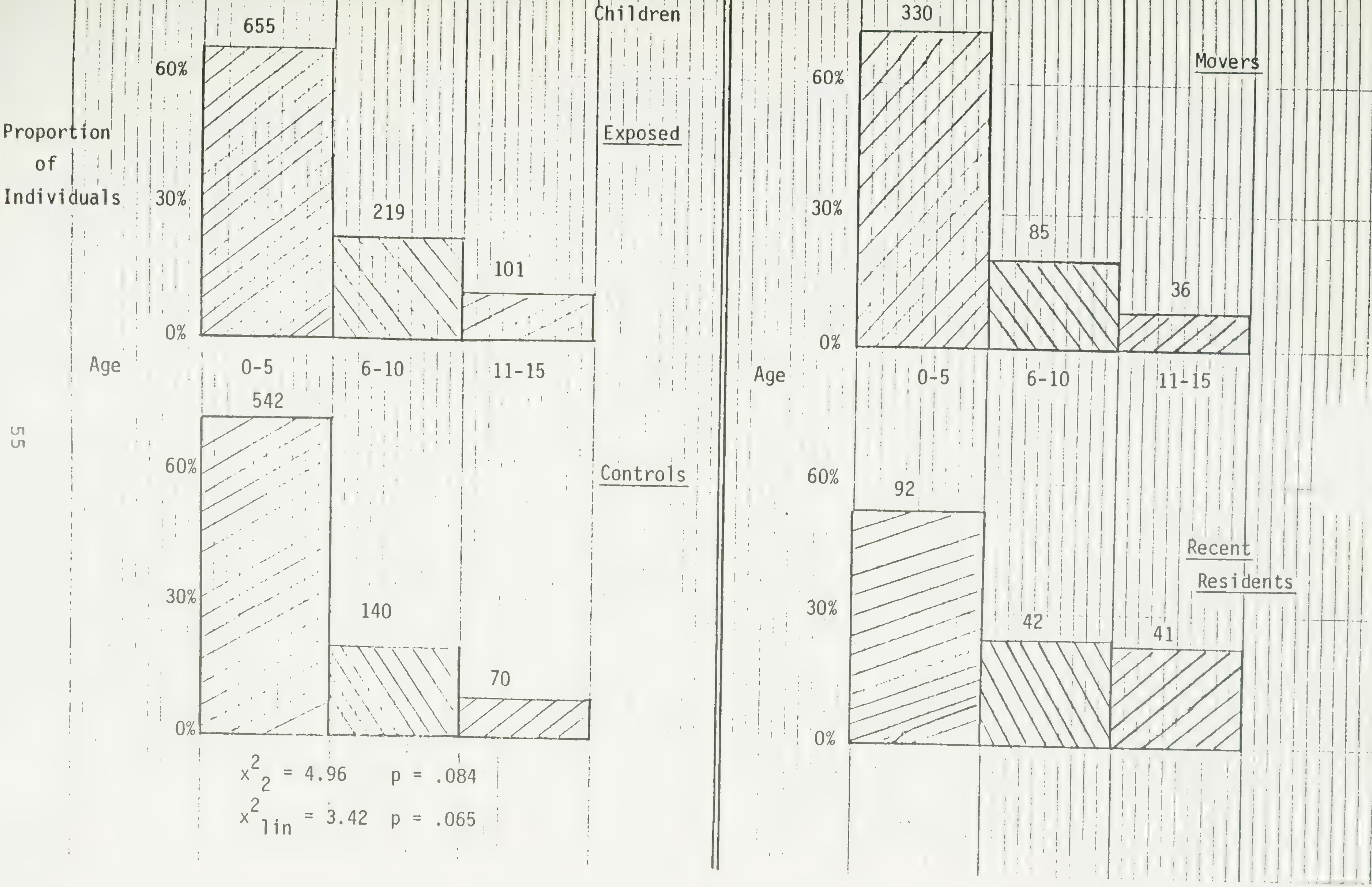
Age Distribution at time of First Residence - Adults



$x^2_6 = 22.49$ $p = .001$

$x^2_{lin} = 4.78$ $p = .029$

Figure 5: Age Distribution at Time of First Residence - Children



households 12.8 percent had incomes of less than $20,000, while 21.2 percent were $40,000 or more. These differences were highly statistically significant, but do not suggest that the main study groups fall into separate income quintiles within the Canadian range. Health status differences by socioeconomic status in Canada have been measured between income quintiles but not within them.

The lower income distribution in exposed households was matched by a higher proportion of renter families (Table 10). This observation precipitated a search for flaws in control selection, since it seemed to conflict with real estate and neighbourhood planning information. The Ontario Housing Corporation had initiated a series of special programs during the early 1970's which allowed builders to sell houses at lower than their usual market value, and provide the OHC with 10 percent of the units for rental purposes. The housing size, type, and re-sale value criteria used to match communities had masked these differences. Even in retrospect, however, no other Hamilton community would have made a better match.

Family size and respondents' degree of co-operation were similar (Table 10). The interviewer-assessed level of comprehension showed no difference in proportion of respondents with substantial difficulties understanding the questionnaire, but a greater proportion of exposed respondents showed less than full comprehension.

Tablè 11 compares groups by individual subject characteristics. The modal education level for each group was completion of grade 11 to 13. Once again, the distribution was higher among the controls. Nineteen percent had completed grade 10 or less, while 31.6 percent had completed college or other post-secondary. Among exposed households 29.1 percent had completed grade 10 or less, while 21.7 percent had completed college or other post-secondary. The exposed group had a higher proportion of blue collar than white collar workers while the control group had the reverse. Fortunately, these differences were not reflected in the experience of dusty jobs or work

with industrial chemicals. Among exposed individuals, 29.8 percent reported work on dusty jobs compared to 25.8 percent in the controls. Chemical fume and gas exposure was reported by 24.6 percent of exposed individuals and 21.4 percent of controls.

No differences were seen in the proportion of subjects born outside of Canada. Small differences were found in the proportion of individuals whose first language was English (77.9 percent of exposed, 80.8 percent of controls). The most common second language of both communities was Italian.

Figures 4 and 5 give the age distribution at time of first residence for adults and children respectively. The modal age at first residence was 26-30 for all groups. The controls were slightly older than the exposed groups; 11.1 percent of controls and 9.7 percent of exposed were over 45, while 29.1 percent of exposed and 20.5 percent of controls were under 25 at first residence. Gender balance was similar: 47.7 percent of exposed adults and 49 percent of controls were male. Among children, the age distribution at first residence was highly comparable for exposed and controls (Figure 5). The high proportion of children who entered the study at age 0-5 demonstrates that the sampling strategy matched communities which were attracting young couples starting families. Among exposed children, 49.7 percent were male, while 48.7 percent of control children were male.

(c) Health Habits

Table 12 describes the smoking and drinking habits of adults in all four study groups. Statistical analysis was confined to the exposed and controls groups. No differences in drinking habits were found. Forty percent of exposed adults, but only 26.8 percent of controls were current daily smokers. The difference in proportions who had ever been daily smokers was similar; 56.9 percent of exposed and 47.3 percent of controls. Table 13 shows that the age of first smoking was similar for current smokers in both study groups.

Table 12: Comparability of Groups by Selected Health-Related Habits

	Variable	Categories	Distribution of Responses				X^2 (exposed vs. controls)	(p)
			Exposed	Controls	Movers	Recent		
1.	Current daily smoker (age at first residence greater than 16)	Yes	397	226	189	101	34.71	$<.001$
		No	599	617	280	186		
2.	Lifetime experience with cigarettes (age at first residence greater than 16)	(a) Current Daily smoker	397	226	189	101	35.38*	$<.001$
		(b) Used to smoke daily	169	173	73	54		
		(c) now smoke occasionally	12	16	5	5		
		(d) used to smoke occasionally	43	48	18	11		
		(e) never	375	380	185	115		
3.	Average alcohol intake in last year (age at first residence greater than 16)	(a) once a day or more	134	110	45	41	2.38*	.67
		(b) 2 or more times a week	157	136	84	53		
		(c) 2 or more times a month	264	236	141	68		
		(d) about once a month or less	243	216	126	73		
		(e) not at all in last year	192	141	71	52		

* χ^2_4 based on all categories

Table 13: Age At Which Smoking Began*

Age	Exposed	Controls	Movers	Recent
		GROUPS		
0-15	158	76	52	32
16-20	242	145	116	67
21-30	52	31	32	7
31-45	7	5	4	0
	459	257	204	106

$x^2_3 = 1.85$**

$p(x^2) = .60$

* question related to all current daily smokers 16 years and older at time of interview.

** based on "exposed" versus "controls".

2. Analysis of Adult data

(a) Main Analysis

Table 14 shows the analysis of the main hypotheses. Conditions are divided into five organ-system groups. Four of the five are composed of more than one condition. The combined organ-system variables included the first event among the contributing conditions which occurred after first residence in the qualifying household. Each individual condition and organ-system group was analyzed using the Cox proportional hazards model as described in the materials and methods section. Only the exposed group (1000 to 4000 series) and controls (5000 to 6000 series) were included. Table 15 shows the confounding variables which were entered in each analysis. For some subanalyses, certain variables did not remain in the final model, based on a "p to enter" of 0.10 and a "p to remove" of 0.15. These are shown in Table 14. To adjust for multiple testing, a one-tailed alpha of 0.01 was adopted for each organ-system group ($\frac{0.05}{n}$, where n = number of organ-system groups). Analysis of conditions within the organ-system groups were used to identify the prinicpal components of exposed-controls differences. This purpose was largely descriptive, but an alpha of 0.01 was applied to identify which conditions could be thought to be independent contributors to exposed-control differences in health status. An alpha of 0.01 is rational because there are four to five conditions within each organ-system group.

Table 14 shows positive associations between residence adjacent to the landfill and four of five organ-system groups: respiratory, skin, narcotic symptoms, and mood symptoms. Each association was strongly positive, with relative risk greater than 1.50 and p less than 0.001. The principal contributing conditions within the respiratory group were "attacks of bronchitis", "shortness of breath", and "periods or episodes of cough and phlegm lasting for three weeks or more". "Recurrent or severe problems

Table 14: Risk Of Adverse Health Outcomes Associated With Landfill Site Exposure

I. Main Hypotheses - Adults

	Condition	Confounding Variables in Model*	N of Events		Eligible Subjects		Person Years at Risk		Relative Risk	p(RR)**
			Exposed	Controls	Exposed	Controls	Exposed	Controls		
1.	Combined Respiratory	all	149	91	997	839	6970	6753	1.56	<.001
	(a) attacks of bronchitis	all	44	21	956	304	7004	6689	2.07	.004
	(b) chronic bronchitis	all	8	7	982	830	7375	6936	1.04	.47
	(c) shortness of breath	all	48	21	972	830	7145	6884	2.00	.005
	(d) cough & phlegm	all	88	53	972	824	7079	6766	1.55	.007
2.	Combined Skin	all	130	68	997	839	6984	6763	1.76	<.001
	(a) recurrent or severe problems with scaly, dry, or itchy skin	b	59	23	964	814	7022	6722	2.32	<.001
	(b) recurrent or severe problems with skin rashes or hives	b	31	15	980	817	7288	6796	1.93	.05
	(c) recurrent or severe problems with unusual acne	b,e,f	8	5	990	834	7419	6965	1.92	.13
	(d) recurrent or severe problems with boils, warts, cysts	b	36	23	979	827	7259	6849	1.53	.06
	(e) white or dark patches on the skin	b	18	10	992	830	7409	6924	1.66	.09
3.	Combined Narcotic Symptoms	all	170	67	997	339	6809	6764	2.29	<.001
	(a) frequent or severe headaches	a,b,e,f	106	41	914	767	6465	6257	2.21	<.001
	(b) frequent dizziness or blurred vision	b,f	38	13	992	834	7362	6949	2.65	.01
	(c) constant fatigue, lethargy, drowsiness	b,e	63	22	986	833	7203	6917	2.54	<.001
	(d) problems with balance co-ordination, reaction time, clumsiness	b	13	8	987	833	7398	6952	1.54	.17
4.	Combined Mood	all	129	66	997	339	7035	6740	1.70	<.001
	(a) trouble sleeping	b,c,f	63	41	974	819	7101	6738	1.30	.10
	(b) frequent feelings of anxiety or depression	a,b	62	23	966	822	7073	6791	2.50	<.001
	(c) frequent feelings of irritability	b,c,e	48	20	983	833	7252	6869	2.22	.01
	(d) frequent feelings of hyper-activity, restlessness, trouble sitting still	b,c,e	17	8	988	838	7350	6898	1.96	.08
	(e) learning or memory disorders	—	4	1	997	839	7483	7027	—	.12
5.	Muscle Weakness (arms, legs, hands or feet)	—	15	8	997	838	7456	6999	1.36	.09

* see Table 15 for guide of confounding variables.

** p(RR) based on -Z-distribution, one-tailed.

Table 15: Confounding Variables Entered In The Models - Adults

I. Respiratory Conditions

age (linear + 5 year categories)	(a)
sex	(b)
ever smoked daily	(c)
ever worked in a dusty job	(d)
ever worked with fumes or gases	(e)
highest level of schooling	(f)

II. Skin Conditions

age (linear + 5 year categories)	(a)
sex	(b)
ever worked with chemical fumes or gases	(e)
highest level of schooling	(f)

III. Narcotic Symptoms

age (linear + 5 year categories)	(a)
sex	(b)
ever smoked daily	(c)
ever worked with chemical fumes or gases	(e)
highest level of schooling	(f)

IV. Mood Symptoms

age (linear + 5 year categories)	(a)
sex	(b)
ever smoked daily	(c)
ever worked with chemical fumes or gases	(e)
highest level of schooling	(f)

V. Muscle Weakness

(see Mood or Narcotic symptoms)

with scaly, dry, or itchy skin" was the principal contributor to the skin group. "Frequent or severe headaches", "frequent dizziness or blurred vision", and "constant fatigue, lethargy, drowsiness" were the principal contributors to the "narcotic" group. "Frequent feeling of anxiety or depression" and "frequent feelings of irritability" were the principal contributors to the "mood" group.

Subanalyses were carried out on the combined respiratory, skin, narcotic, and mood groups and not on the individual conditions within those groups. Muscle weakness was excluded from further analysis.

(b) Gradient Analyses

Tables 16, 17, and 18 relate the organ system groups of interest to proximity of residence to the landfill and duration of residence adjacent to the site. Table 16 gives three-point analyses by those living with 500 metres of the landfill (1000 and 2000 series), 500 - 750 metres from the landfill (3000 and 4000 series), and controls. Statistical methods, inclusion of events, and confounding variables were similar to the main analyses; except that the outcome variable was the linear trend of incidence rate by proximity to the landfill. All four organ-system groups show statistically significant linear trends (p 0.001 in all cases). A monotonic trend in crude incidence rates is evident for respiratory, narcotic and mood systems. The crude incidence rates of skin symptoms do not show a monotonic trend. The statistical linear trend is based on the main differences between exposed and controls. This

Table 16: Risk Gradient By Proximity Of Residence To Landfill Site: Short And Long-term Residents - Adults

Condition	Location of Residence	N of Events	Incidence* (Events per 1000 person-years)	Z (linear trend)	p(Z)
1. Combined Respiratory	within 500 metres of landfill	61	25.6	4.01	$<.001$
	500-750 metres from landfill	88	19.2		
	controls	91	13.5		
2. Combined skin	within 500 metres	44	18.1	3.16	$<.001$
	500-750 metres	86	18.9		
	controls	68	10.1		
3. Combined Narcotic	within 500 metres	67	28.9	5.89	$<.001$
	500-750 metres	103	23.0		
	controls	67	9.9		
4. Combined Mood	within 500 metres	58	24.1	4.49	$<.001$
	500-750 metres	71	15.7		
	controls	66	9.8		

* Crude estimates. Values used to calculate linear trend within the Cox model are not recoverable from the computer.

Table 17: Risk Gradient by Proximity of Residence to Landfill Site: Long-term Residents Only-Adults

Condition	Location of Residence	N of Events	Incidence (Events per 1000 person-years)	Z-(Linear Trend)	p(Z)
1. Combined Respiratory	within 500 meters of landfill	44	26.1	3.73	<.001
	500-750 metres from landfill	45	14.5		
	Controls	69	12.4		
2. Combined Skin	within 500 metres	34	19.8	3.04	<.001
	500-750 metres	52	17.0		
	Controls	56	10.1		
3. Combined Narcotic	within 500 metres	52	32.3	5.44	<.001
	500-750 metres	58	19.2		
	Controls	57	10.3		
4. Combined Mood	within 500 metres	42	24.7	3.27	<.001
	500-750 metres	35	11.2		
	Controls	57	10.3		

Table 18: **Risk Gradient by Proximity of Residence to Landfill Site: Short-term Residents Only-Adults**

Condition	Location of Residence	N of Events	Incidence	Z(linear trend)	p(Z)
1. Combined Respiratory	within 500 metres of the landfill	17	24.3	1.04	.30
	500-750 metres from the landfill	43	29.0		
	Controls	22	18.5		
2. Combined Skin	within 500 metres	10	13.9	1.09	.28
	500-750 metres	34	22.8		
	Controls	12	9.8		
3. Combined Narcotic	within 500 metres	15	21.1	2.27	.05
	500-750 metres	45	30.6		
	Controls	10	8.1		
4. Combined Mood	within 500 metres	16	22.7	2.40	.05
	500-750 metres	36	24.1		
	Controls	9	7.4		

observation led us to consider whether or not skin symptoms might be more closely related to direct skin contact through recreational activities in and around the landfill area. An analysis of exposed adults showed that 28.6 percent of those reporting such recreational activities also reported one or more skin symptom, while 11.9 percent of those not reporting these activities reported skin symptoms. (x^2 = 16.02, p = .00006).

Table 17 repeats the analyses in Table 16, but confined to the subgroups adjacent to the landfill or in the control community for three or more years during the peak period of dumping (1000, 3000, and 6000 series). Strongly positive, monotonic linear trends are evident in all analyses. Table 18 repeats the same process for those who spent less than 3 years in their qualifying community during the peak period of dumping. (2000, 4000, and 5000 series). No linear, monotonic trends were found. These data support a "duration of residence" gradient in incidence rate for the main health conditions of interest. Analyses comparing long-term directly with short-term residents were avoided because they involved non-concurrent comparisons. Although the Cox model can adjust for non-concurrent starting times, it is not safe to assume that the level and type of exposure to landfill emissions was constant at all times. Thus, short-term exposure may have been confounded by higher (or lower) average emissions. This would not explain the observation that the crude incidence rates in Table 18 for the short-term residents 500 - 750 metres from the landfill (4000 series) were often higher than for the other short-term residents nearer the site.

The gradient by "proximity to landfill" is better addressed by Table 19 than by Tables 16 to 18. In this analysis, the designation of household by sugbroup was removed and replaced by the distance of each individual home from the closest edge of the landfill. This allowed calculation of a monotonic trend within the exposed group, free of confounding due to differences with the controls. The analysis was carried out after peer review of the report and suffers from the weakness that the sample of landfill area residents was not identified at the outset of the study to meet criteria for it. In

Table 19: **Risk Gradient by Proximity of Residence to Landfill Site: Exposed Group Only by Individual Household Distance From Site (Adults)**

Condition	x^2(trend)	(p)	Risk Reduction per 100 Metres from Landfill*
	Long-term Residents		
1. Combined Respiratory	4.74	.015	-17%
2. Combined Skin	0.79	.186	-8%
3. Combined Narcotic	6.66	.005	-18%
4. Combined Mood	4.94	.013	-18%
	Short-term Residents		
1. Combined Respiratory	.14	.65	+4%
2. Combined Skin	.74	.80	+11%
3. Combined Narcotic	1.61	.90	+12%
4. Combined Mood	.27	.70	+5%

* based on the slope of the exponential coefficient for distance from landfill given confounding variables, in the proportional hazards model. This should be interpreted as "for each 100 metres from the landfill, the risk decreased X% from the level 100 metres closer."

particular, we did not extend sampling beyond 750 metres and into areas we thought were "unexposed". Also, we did not assume that meteorologic patterns in the area would distribute air pollutants in a monotonic decline, metre-to-metre from the landfill. So interpretation of this data has been made in a more descriptive fashion than other data in the report.

Table 19 shows a monotonic trend in risk reduction by distance from the landfill among long-term residents for respiratory, narcotic, and mood symptoms. The trend for skin symptoms was much weaker, as expected from Tables 16 to 18. The trends among short-term residents were weak, and were not in the direction of risk reduction by distance from the site. These results suggest a gradient of effect by proximity to the landfill site for the long-term residents.

(c) Migrator Effects

Table 20 compared the movers (8000 series) to the exposed group (or "non-movers") and Table 21 compared the movers to the controls. The pretest expectation was that the movers would have similar health status to the exposed group. Table 20 shows that this was true for skin, narcotic, and mood conditions. Respiratory conditions differed in that there was a trend to a lower incidence rate among migrators. These observations were mirrored in Table 21, where large differences in incidence rates were found between movers and controls for skin, narcotic, and mood, but not for respiratory conditions. These data suggest that migrators were more like exposed residents than controls in health status. Table 26 divides the follow-up period at the end of 1980 so that tempered changes in the risk of new health problems can be compared between migrators and non-migrators. This table, and the discussion in Section (g) more directly address the evidence of a migrator bias.

Table 20: **Association Between Migrator Status and Risk of Adverse Health Outcomes - Adults**

I: Landfill Residents, 1976-80 who moved versus Landfill Residents, 1976-80 who did not move

	Conditions	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)*
1.	Combined Respiratory	movers	49	15.5	.72	.046
		non-movers	149	21.3		
2.	Combined Skin	movers	55	17.4	.92	.60
		non-movers	130	18.6		
3.	Combined Narcotic	movers	81	26.8	1.04	.79
		non-movers	170	25.0		
4.	Combined Mood	movers	63	20.1	1.08	.62
		non-movers	129	18.3		

* 2-tailed p(Z)

Table 21: Association Between Migrator Status and Risk of Adverse Health Outcomes-Adults

II: Landfill Residents, 1976-80 who moved versus Controls

Condition	Comparison Groups	N. of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)*
1. Combined Respiratory	movers	49	15.5	1.15	.23
	controls	91	13.5		
2. Combined Skin	movers	55	17.4	1.67	.0026
	controls	68	10.1		
3. Combined Narcotic	movers	81	26.8	2.33	$<$ .001
	controls	67	9.9		
4. Combined Mood	movers	63	20.1	1.90	$<$ .001
	controls	66	9.8		

* 1-tailed p(Z)

Table 22: **Comparison of Those Who Moved to the Landfill Site After the Site Was Closed, With Controls.**

Adults

	Condition	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)*
1.	Combined Respiratory	recent residents	35	10.7	.97	.90
		controls	105	11.9		
2.	Combined Skin	recent residents	37	11.4	1.22	.32
		controls	91	9.5		
3.	Combined Narcotic	recent residents	36	10.9	1.11	.60
		controls	96	10.1		
4.	Combined Mood	recent residents	29	8.7	1.04	.86
		controls	77	8.0		

* 2-tailed p(Z)

(d) Health status differences - controls versus recent residents

Table 22 compares controls with those who moved into the landfill area after the site was closed. All health problems reported from 1972 to the time of interview were included, regardless of whether or not they were reported before the household had moved to the qualifying location. This approach allowed for a concurrent analysis, based on the premise that the health of the two groups ought to be similar unless the landfill site area attracted residents who were less healthy than other members of the community. Table 22 shows no statistically significant difference in incidence rates of the main groups of conditions. Moreover, the relative risks are all close to 1.0. The landfill site area does not appear to attract people who are less healthy.

(e) Secondary Hypotheses

Criteria for identifying secondary hypotheses were described in the "Background" section of this report. Table 23 gives the results of the Cox model analysis comparing the exposed group (1000 to 4000 series) with controls (5000 to 6000 series) for these ten secondary hypotheses. Analyses were declared "positive" when the $p(RR) \leqslant 0.005$, which is 0.05/10. Only one condition, "red, itchy, watery, sore dry or inflamed eyes", achieved this level of statistical significance. Subanalyses comparable to those done on the main hypotheses were subsequently conducted on this condition. These are described in the next section. Inspection of Table 23 demonstrates that statistically non-significant trends towards increased incidence rates were seen for several other irritant and respiratory conditions.

(f) Subanalyses of "Red, Itchy Eyes"

Table 24 shows the subanalyses for "red, itchy eyes". Like the main hypotheses, gradient analyses by exposure subgroup showed a monotonic trend among short- and long-term residents combined and long-term residents only,

Table 23: **Risk of Adverse Health Outcomes Associated With Landfill Site Exposure**

Secondary Hypotheses-Adults

	Condition	Confounders in Model	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)
1.	Hayfever	a	exposed controls	68 41	10.4 6.8	1.46	.030
2.	Asthma	b	exposed controls	19 8	2.6 1.2	2.13	.037
3.	Wheezy or whistling chest for most days or nights throughout the year	a,b,c,d,f	exposed controls	19 12	2.6 1.7	1.27	.26
4.	Five or more colds per year	a,b,d,f	exposed controls	59 33	8.3 4.8	1.48	.037
5.	Nosebleeds (not from injury)	d	exposed controls	24 11	3.3 1.6	2.00	.029
6.	Unusual nose irritation or nasal discharge	a,b	exposed controls	25 13	3.4 1.9	1.64	.075
7.	Throat infections or prolonged, irritated sore throat	b	exposed controls	64 47	8.8 6.8	1.36	.059
8.	Red, itchy, watery sore, dry or inflamed eyes	all	exposed controls	76 42	10.8 6.3	1.87	< .001
9.	Numbness, tingling prickling or loss of sensation on arms, legs, hands, feet	--	exposed controls	15 8	2.0 1.1	1.82	.087
10.	Difficulty starting a pregnancy (females only)	a,f	exposed controls	12 11	3.2 3.3	.69	.144

Table 24: Subanalysis for "Red, Itchy...Eyes"

Adults

	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)	Z(linear trend)	p(Z)
1.	Gradient Analysis						
	(a) within 500 metres	28	11.4	---	---	2.69	.004
	(b) 500-750 metres	48	10.4				
	(c) controls	42	6.3				
2.	Gradient Analysis (Long-term only)						
	(a) within 500 metres	22	12.6	---	---	2.68	.004
	(b) 500-750 metres	28	9.0				
	(c) controls	35	6.4				
3.	Gradient Analysis (short-term only)						
	(a) within 500 metres	6	8.6	---	---	.97	.17
	(b) 500-750 metres	20	13.3				
	(c) controls	7	6.1				
4.	Migration						
	Movers	29	9.0	.82	.19	---	---
	Non-movers	76	10.8				
5.	Migration						
	Movers	29	9.0	1.38	.09	---	---
	Controls	42	6.3				
6.	Recent Residents	20	6.1	1.16	.14	---	---
	Controls	52	5.4				

but not among short-term residents. Analysis by proximity of residence to the landfill among exposed residents showed a risk reduction of 16% per 100 metres distance from the landfill ($x^2 = 2.36$, $p = .062$) for the long-term residents. Among short-term residents, there was no evidence of risk reduction by distance from the landfill. No differences in rates of health problem reports were found when movers were compared with exposed residents who did not move. However, differences in incidence rates between movers and controls (expected if migrators were like non-migrators) were not statistically significant. Either a migrator bias exists or else the original effects of landfill site exposure have been masked by inclusion of follow-up time after the migrators left the landfill area. This issue is addressed in section (g) and Table 26, where analyses of health events before and after the end of 1980 are considered separately. Comparison of recent residents to controls (1972 to 1984) did not reveal any evidence that those attracted to live near the landfill were more prone to eye irritation.

(g) Analysis of Events Occurring Before 1981, and 1981-84.

Table 25 repeats the main comparison of the primary and secondary hypotheses including only health events occurring before 1981. Thus, the analyses are confined to the time when the landfill site was open to waste disposal. Since most of the conditions contributing to the organ-system groups (and red, itchy eyes) were acute, it could be expected that any differences seen in incidence rates should have emerged before the site closed (and presumably, exposure declined). If this were not seen, one of three hypotheses would have to be entertained:

i. Exposure continued at significant levels after the site closed.
ii. The conditions of interest have a latent period between exposure and outcome.
iii. The conditions were unrelated to chemical exposure at the landfill.

Table 25 should be compared with Table 14 (and, in the case of "red,itchy eyes, with Table 23) to see what happened. Relative risks for respiratory, skin, and narcotic conditions were elevated when events occurring before 1981 were considered. The relative risks for mood conditions and red, itchy eyes were slightly lower, though not enough to require invoking one of the hypotheses just described, to explain it.

Table 26 presents the relationship between migrators and non-migrators including all events before the end of 1980, then all the events after that time. The period before 1980 represents both the time when the landfill site was open and the time when (virutally) all the migrators were still resident near it. The period after 1980 (1981-84) represents the time after the site was closed and after the migrators had left the area. The table shows that, in all cases, the relative risk (non-migrators/migrators) increases between the two periods. For all except "red, itchy eyes", the relative risk before the end of 1980 is less than 1.00. This means that the migrators were complaining of more first events of the target health problems than the non-migrators before they left the area, but fewer thereafter. The former observation may be interpreted as a conservative migrator bias (supports positive results in the main analyses). This is because, were the migrators to be included with the other exposed groups (non-migrators) in a comparison with controls, the estimated relative risks would have been increased.

The observation of relative risks greater than 1.0 after the end of 1980 is less readily explicable. This could represent a "survival effect" inherent in analyzing the latter part of a follow-up period after early health outcomes have been counted. The only relative risk greater than 1.0 for which the 95 percent confidence interval did not include 1.0 was for respiratory conditions. Alternately, the three hypotheses described two paragraphs ago must be considered. Of these, the first and third are most reasonable. This issue will be addressed in more detail in the Disucssion section of this report.

Table 26: Migrator Effects (Adults)–Relative Risks Before and After 1981, Non-Movers Versus Movers

Condition		Relative Risk (Non-movers / Movers)	(p)*	95% Confidence Limits
1. Combined Respiratory	(a) to 1980	.83	.400	.55-1.28
	(b) 1981-84	2.60	.0003	1.45-4.65
2. Combined Skin	(a) to 1980	.98	.912	.63-1.52
	(b) 1981-84	1.28	.296	.79-2.08
3. Combined Narcotic	(a) to 1980	.89	.201	.56-1.13
	(b) 1981-84	1.28	.267	.81-2.02
4. Combined Mood	(a) to 1980	.62	.033	.40-.96
	(b) 1981-84	1.23	.365	.77-1.93
5. Red, itchy eyes	(a) to 1980	1.02	.96	.52-1.98
	(b) 1981-84	1.37	.21	.75-2.51

* 2-tailed

Table 25: Analysis of Events Occurring Before 1981

Main Hypothesis, Adults, Exposed versus Controls

Condition	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)
1. Combined Respiratory	Exposed	72	20.8	2.12	<.001
	Controls	36	9.9		
2. Combined Skin	Exposed	68	20.1	2.26	<.001
	Controls	30	8.3		
3. Combined Narcotic	Exposed	98	29.4	2.91	<.001
	Controls	36	10.0		
4. Combined Mood	Exposed	56	16.5	1.51	.027
	Controls	38	10.6		
5. Red, Itchy Eyes	Exposed	33	9.8	1.60	.045
	Controls	22	6.2		

(h) Controls versus recent residents after the landfill site closed

A second comparison of controls and recent residents is found in Table 27. This analysis included only events occurring after the recent residents moved into the landfill area. To make it concurrent, only events occurring after 1980 were included for controls. This analysis looked for evidence of effects of ongoing exposure after the site was closed and capped. A trend toward increased incidence rates for narcotic symptoms was found. This did not reach $p \leqslant 0.01$, adjusted for multiple testing. No other trends were seen. This is in contrast with Table 26, which suggests that those who lived near the landfill during the period when it was open, continued to have increased rates of target health problems after the site was closed.

(i) Screening Analyses for Hypothesis Generating

Table 28 shows four other conditions or groups of conditions which were regarded as important outcomes of the study but were not part of the hypothesis base. These were screened for evidence of association with landfill site exposure using the Cox model approach. No effect was seen for "frequent, prolonged bruising", "problems with resistance to disease or seem to get sick easily", or for "cancer, leukemia, lymphoma, Hodgkins Disease". One of four renal conditions, "repeated bladder/urinary tract infections", showed a relative risk of 3.17 ($p = .002$) but too few events were reported to attempt subanalyses.

(j) Conditions not thought related to landfill site exposure

Table 29 identifies the 25 conditions which met the criteria described in the Methods section as "not being related to landfill site exposure". Many of these conditions are closely related biologically, and cannot be viewed as 25 independent conditions for the purposes of analysis. This analysis was designed to answer the question, "Are differences found between the exposed

Table 27: **Events Occurring After 1980, Recent Residents Versus Controls - Adults**

Condition	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)*
1. Combined Respiratory	recent residents	13	18.9	.81	.25
	controls	55	23.6		
2. Combined Skin	recent	9	12.9	.77	.25
	controls	38	16.1		
3. Combined Narcotic	recent	17	24.8	1.69	.043
	controls	31	13.1		
4. Combined Mood	recent	11	16.0	1.04	.47
	controls	28	11.9		
5. Red, Itchy Eyes	recent	6	9.3	1.07	.88
	controls	20	8.6		

* 2-tailed p(RR)

Table 28: Screening Analyses for Hypothesis Generating - Adults

	Condition	Groups	N of Events	N without	Relative Risk	x^2	$p(x^2)$
1.	frequent prolonged bruising	exposed	17	956	1.81	1.99	.159
		controls	8	819			
2.	problems with resistence to disease or "seem to get sick easily"	exposed	19	971	1.78	2.12	.145
		controls	9	826			
3.	cancer, leukemia lymphoma, Hodgkins Disease	exposed	9	984	.95	.013	.909
		controls	8	827			
			RENAL GROUP*				
4(a)	repeated bladder urinary tract infections	exposed	30	935	3.17	9.57	.002
		controls	8	807			
4(b)	blood in urine	exposed	19	970	1.59	1.48	.224
		controls	10	820			
4(c)	painful urination	exposed	9	976	1.26	.20	.655
		controls	6	824			
4(d)	nocturia	exposed	40	920	1.31	1.22	.270
		controls	26	793			

* Relative Risk for combined renal group using Cox proportional hazards model = 1.41, p(RR) = .038

Table 29: Conditions Not Thought to be Related to Landfill Site Exposure - Adults

	Conditions	Groups	N of Events	N without Events	Risk Ratio	X^2	$p(x^2)$
1.	angina	exposed	8	985	.68	.702	.402
		controls	10	828			
2.	high blood pressure	exposed	72	900	1.22	1.26	.263
		controls	49	759			
3.	heart murmur	exposed	16	964	1.67	1.46	.227
		controls	8	811			
4.	infectious mononucleosis	exposed	5	986	.84	.073	.787
		controls	5	831			
5.	anemia	exposed	20	956	1.28	.501	.479
		controls	13	801			
6.	kidney stones	exposed	18	968	1.09	.053	.817
		controls	14	818			
7.	food allergies	exposed	11	965	.92	.038	.845
		controls	10	805			
8.	diabetes	exposed	9	983	.94	.015	.902
		controls	8	823			
9.	gall stones or other gall bladder diseases	exposed	31	943	.99	.016	.899
		controls	27	794			
10.	stomach ulcers	exposed	25	938	.78	1.03	.310
		controls	28	792			
11.	frequent indigestion	exposed	56	915	1.68	5.45	.020
		controls	28	790			
12.	alcohol intolerance	exposed	8	982	1.12	.042	.838
		controls	6	823			
13.	frequent diarrhea	exposed	22	971	.94	.07	.795
		controls	20	814			

Table 29: Conditions Not Thought to be Related to Landfill Site Exposure - Adults

Conditions	Groups	N of Events	N without Events	Risk Ratio	X^2	$p(x^2)$
14. frequent constipation	exposed	18	946	1.52	1.16	.282
	controls	10	803			
15. loss of appetite	exposed	14	981	5.90	7.18	.007*
	controls	2	836			
16. loss of weight	exposed	16	977	6.74	8.78	.003*
	controls	2	835			
17. epilepsy	exposed	5	985	2.11	.841	.359
	controls	2	835			
18. earaches/ear infections	exposed	34	944	1.44	1.73	.190
	controls	20	807			
19. tinnitus	exposed	22	966	1.23	.384	.535
	controls	15	812			
20. difficulty with hearing	exposed	19	955	.86	.223	.636
	controls	19	818			
21. arthritis/rheumatism	exposed	74	890	.91	.316	.574
	controls	67	730			
22. head injury with loss of consciousness	exposed	9	986	1.25	.187	.665
	controls	6	826			
23. burns requiring admission to hospital	exposed	11	984	4.63	4.854	.028
	controls	2	836			
24. accident with bone fractures	exposed	46	928	.75	2.13	.144
	controls	52	775			
25. injury causing permanent disability	exposed	35	941	1.10	.136	.713
	controls	27	799			

* Relative Risk for 'loss of appetite or loss of weight', using Cox proportional hazards model = 6.78, p(RR) .001

and control groups in the main analyses merely a reflection of global increases in health problem reports, or are they specific to the hypothesized conditions?" To answer this question, the table is meant to be interpreted as a whole, rather than line-by-line. Inspection of the "risk ratio" column reveals ten values below 1.0 and 15 above it, suggesting no overall trend among these conditions. However, risk ratios greater than 4.0 are found for three conditions: "loss of appetite", "loss of weight", and "burns requiring admission to hospital". Because the first two of these conditions are so closely related biologically, they were combined in a Cox model analysis which was reported at the bottom of Table 29. It turned out strongly positive. These conditions were missed in the hypothesis-generating exercise because they did not have biological credibility as outcomes of airborne or recreational exposure to an uncharacterized mixture of volatile organics, dusts, and fumes. This finding may be evidence of the psychological effect of residence adjacent to a landfill or it may be related to exposures not properly understood yet.

3. Analysis of Child Data

(a) Main Analysis

Table 30 shows the analyses of the main hypotheses among children (that is, those younger than 16 at time of first exposure). The conditions are the same as those of the adults. Because they were identified in a study of adults (landfill workers), they are likely more applicable to adult residents than to children. For this reason, the secondary hypotheses found later are an important supplement.

Methods of analysis were the same as for the adults. Table 31 gives the list of confounders available for entry into each model, while the confounders actually entering are listed in a column on Table 30. Positive associations with landfill site exposure ($p \leqslant 0.01$) were seen for skin, narcotic, and mood symptoms. The association with narcotic symptoms was particularly strong, with a relative risk of 3.27. Respiratory conditions were less closely

Table 30: **Risk of Adverse Health Outcomes Associated with Landfill Site Exposure**

Main Hypotheses - Children

	Condition	Confounding Variables in Model	N of Events		Eligible Subjects		Person Years at Risk		Relative Risk	p(RR)
			Exp.	Controls	Exp.	Controls	Exp.	Controls		
1.	Combined Respiratory	all	119	74	973	752	6161	5312	1.31	.044
	(a) Attacks of bronchitis	a	49	36	957	740	6301	5322	.99	.51
	(b) Chronic bronchitis	--	5	2	970	748	6571	5532	1.57	.30
	(c) Shortness of breath	--	25	11	972	750	6520	5507	1.87	.042
	(d) Cough & phlegm	c	65	31	963	747	6308	5450	1.68	.014
2.	Combined Skin	all	141	69	974	752	6161	5353	1.64	<.001
	(a) recurrent or severe problems with scaly, dry or itchy skin	--	33	15	966	747	6424	5475	2.07	.014
	(b) recurrent or severe problems with skin rashes or hives	--	36	17	974	743	6505	5448	1.71	.038
	(c) recurrent or severe problems with unusual acne	a,b,c	15	11	974	752	6583	5523	.71	.21
	(d) recurrent or severe problems with boils, warts cysts	a,c	62	22	971	748	6472	5493	2.24	<.001
	(e) white or dark patches on the skin	--	6	6	972	751	6590	5546	.95	.47
3.	Combined Narcotic Symptoms	all	88	27	974	752	6315	5476	3.17	<.001
	(a) frequent or severe headaches	a,b	77	24	967	749	6309	5451	3.13	<.001
	(b) frequent dizziness or blurred vision	a,b	6	1	973	752	6605	5567	3.86	.11
	(c) constant fatigue, lethargy, drowsiness	--	10	4	973	752	6577	5563	2.50	.09
	(d) problems with balance co-ordination, reaction time, clumsiness	c	4	1	967	749	6550	5541	2.08	.26
4.	Combined Mood	all	69	27	974	752	6373	5464	2.07	<.001
	(a) trouble sleeping	--	10	3	973	751	6589	5558	2.66	.07
	(b) frequent feelings of anxiety or depression	a,c	10	2	973	752	6587	5558	2.92	.09
	(c) frequent feelings of irritability	a,c	16	1	974	751	6569	5560	8.36	.021
	(d) frequent feelings of hyperactivity, restlessness, trouble sitting still	a,b,c	36	11	955	741	6365	5441	3.10	<.001
	(e) learning or memory disorders	a	13	11	970	747	6550	5495	1.17	.36
5.	Muscle Weakness (arms, legs, hands,or feet)	a	7	2	975	752	6591	5562	4.50	.08

Table 31: Confounding Variables Entered in the Models - Children

I. Respiratory Conditions

age (linear & 5-year categories)	(a)
sex	(b)
family income	(c)
any parent a daily smoker	(d)

II. Skin Conditions

age (linear & 5-year categories)	(a)
sex	(b)
family income	(c)

III. Narcotic Conditions

age (linear & 5-year categories)	(a)
sex	(b)
family income	(c)

IV. Mood Conditions

age (linear & 5-year categories	(a)
sex	(b)
family income	(c)

V. Muscle Weakness

age (linear & 5-year categories)	(a)
sex	(b)
family income	(c)

associated (relative risk = 1.30, p= 0.045), but they were reanalyzed in Table 42 using events from 1980 and before. The principal contributing conditions were:

skin - "recurrent or severe problems with boils, warts, cysts"
- "recurrent or severe problems with scaly, dry, itchy skin"
narcotic - "frequent or severe headaches"
mood - "frequent feelings of hyperactivity, restlessness, trouble sitting still"
respiratory - "periods or episodes of cough or phlegm lasting for 3 weeks or more".

As in the case of adults, "muscle weakness" was not found to be associated with landfill site exposure and was excluded from further analysis.

(b) Gradient Analyses

Tables 32, 33, 34 and 35 show the risk by proximity of residence to the landfill and duration of exposure. These analyses are less valid for children than adults because attendance at neighbourhood schools and participation in outdoor activities in the local area tended to make location of residence a less valid predictor of each child's exposure to the landfill site. Table 32 includes short- and long-term households together. Although the linear trend is "statistically significant" for skin and narcotic symptoms, and "borderline" for mood symptoms, only skin symptoms show a monotonic trend in incidence rate.

Table 33 is confined to long-term households. Here, monotonic trends are evident for respiratory, skin, and mood symptoms. Only skin symptoms meet both statistical and monotonic trend criteria. This was the reverse of the adult analysis, where montonic trends were found for all but skin symptoms. Once again, skin symptoms were closely associated with

Table 32: Risk Gradient by Proximity of Residence to Landfill Site: Short and Long-term Residents - Children

	Conditions	Location of Residence	N of Events	Incidence (events per 1000 person-years)	Z (linear trend)	p(Z)
1.	Combined Respiratory	within 500 metres of the landfill	42	19.0	1.40	.081
		500-750 metres from the landfill	77	19.5		
		controls	74	13.9		
2.	Combined Skin	within 500 metres	60	28.2	3.98	<.001
		500-750 metres	81	20.1		
		controls	69	12.9		
3.	Combined Narcotic	within 500 metres	31	13.9	4.52	<.001
		500-750 metres	57	14.0		
		controls	27	4.9		
4.	Combined Mood	within 500 metres	22	9.8	2.28	.011
		500-750 metres	47	11.4		
		controls	27	4.9		

Table 33: **Risk Gradient by Proximity of Residence to Landfill Site: Long-term Residents Only - Children**

Condition	Location of Residence	N of Events	Incidence (Events per 1000 person-years)	Z (linear trend)	p(Z)
1. Combined Respiratory	within 500 metres of of landfill	30	17.8	1.68	.047
	500-750 metres from landfill	45	15.7		
	controls	56	12.5		
2. Combined Skin	within 500 metres	46	28.5	4.89	.001
	500-750 metres	53	18.1		
	controls	49	10.8		
3. Combined Narcotic	within 500 metres	23	13.5	3.89	.001
	500-750 metres	43	14.5		
	controls	23	5.0		
4. Combined Mood	within 500 metres	17	9.9	2.28	.011
	500-750 metres	29	9.7		
	controls	21	4.5		

Table 34: **Risk Gradient by Proximity to Landfill Site: Short-term Residents Only - Children**

	Conditions	Location of Residence	N of Events	Incidence (Events per 1000 person-years)	Z(linear trend)	p(Z)
1.	Combined Respiratory	within 500 metres of the landfill	12	23.1	.18	.43
		500-750 metres from landfill	32	29.6		
		controls	18	21.9		
2.	Combined Skin	within 500 metres	14	27.4	-.29	.61
		500-750 metres	28	25.2		
		controls	20	24.8		
3.	Combined Narcotic	within 500 metres	8	15.2	2.12	.017
		500-750 metres	14	12.4		
		controls	4	4.7		
4.	Combined Mood	within 500 metres	5	9.5	.20	.42
		500-750 metres	18	16.0		
		controls	6	7.1		

Table 35: Risk Gradient by Proximity of Residence to Landfill Site: Exposed Group Only by Individual Household Distance From Site (Children)

CONDITION	x^2(trend)	(p)	Risk Reduction per 100 Metres from Landfill*
	Long-term Residents		
1. Combined Respiratory	.83	.180	-9%
2. Combined Skin	.87	.175	-8%
3. Combined Narcotic	.16	.345	-4%
4. Combined Mood	1.12	.145	-13%
	Short-term Residents		
1. Combined Respiratory	.67	.707	+12%
2. Combined Skin	.43	.757	+8%
3. Combined Narcotic	1.74	.099	-21%
4. Combined Mood	.00	.486	+1%

* based on the "slope" of the exponential coefficient for distance from landfill, given confounding variables in the proportional hazards model. This should be interpreted as "for each 100 metres from the landfill, the risk decreased X% from the level 100 metres closer."

recreational activities adjacent to the landfill site. Twenty-four percent of landfill area children reporting such activities and 13.3 percent reporting no such activities also reported one or more skin symptoms. ($x^2 = 9.04$, $p = .003$).

Table 34 shows the short-term households. None of the analyses meets the statistical criterion for linear trend. This time, the most clearly discernible monotonic trend is for narcotic symptoms. Overall, only skin symptoms met the pre-set criteria of a linear trend present among combined long- and short-term households, as well as in long-term households alone.

Table 35 analyzes risk gradient by individual house distance from the landfill, excluding controls. No gradients achieved adequate levels of statistical significance to warrant interpretation. This is consistent with the findings of Tables 32, 33 and 34.

(c) Migrator Effects

Migrator bias among children was assessed the same way as for adults. Table 36 compares "movers" with "non-movers", and Table 37 compares "movers" with "controls". No statistically significant differences were seen between movers and non-movers for any of the four major organ-systems. Estimates of relative risk ranged from .79 to 1.25. Table 37 shows differences in relative risk between movers and controls for skin, narcotic, and mood conditions. No elevated risk was noted for respiratory conditions. Overall these data suggest that migrators were more like exposed residents than controls in health status. The issue of migrator bias is further explored in Section (g) and Table 43.

(d) Health Status Differences - Controls Versus Recent Residents

Table 38 compares "recent residents" with "controls" using events from 1972 until the date of interview. By ignoring the date of first residence in the qualifying household and including many years prior to landfill site

Table 36: **Association Between Migrator Status and Risk of Adverse Health Outcomes - Children**

I. Landfill Residents, 1976-80 who moved versus Landfill Residents, 1976-80 who did not move.

	Condition	Comparison Groups	N of Events	Incidence per 1000 person-years	Relative Risk	p(RR)*
1.	Combined Respiratory	movers	40	15.1	.79	.24
		non-movers	119	19.3		
2.	Combined Skin	movers	52	19.8	.91	.60
		non-movers	141	22.9		
3.	Combined Narcotic	movers	25	9.2	.72	.15
		non-movers	88	13.9		
4.	Combined Mood	movers	35	13.2	1.25	.30
		non-movers	69	10.8		

* 2-tailed p(RR)

Table 37: Association Between Migrator Status and Risk of Adverse Health Outcomes - Children

II. Landfill Residents, 1976-80 who moved versus Controls.

	Condition	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)
1.	Combined Respiratory	movers	40	15.1	1.04	.43
		controls	74	13.9		
2.	Combined Skin	movers	52	19.8	1.61	.006
		controls	69	12.9		
3.	Combined Narcotic	movers	25	9.2	2.33	.004
		controls	27	4.9		
4.	Combined Mood	movers	35	13.2	2.56	<.001
		controls	27	4.9		

Table 38: Comparison of Those Who Moved to the Landfill Site Area After the Site Was Closed, With Controls - Children

	Conditions	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)*
1.	Combined Respiratory	recent residents	14	6.9	.72	.26
		controls	94	10.8		
2.	Combined Skin	recent residents	28	14.1	1.32	.20
		controls	88	10.2		
3.	Combined Narcotic	recent residents	10	4.9	1.43	.33
		controls	34	3.8		
4.	Combined Mood	recent residents	12	5.9	1.45	.28
		controls	40	4.5		

* p(RR) - 2 tailed

exposure for recent residents, the analysis is, in effect, a comparison of the health status of two unexposed populations. Like the comparable adult analysis, no statistically significant differences are seen. The relative risks range from .72 to 1.45. There is no evidence that the landfill site attracted less healthy children as residents.

(e) Secondary Hypotheses

Criteria for identifying secondary hypotheses were described in the "Background" section of this report. Table 39 gives the results comparing the exposed group with controls. Since there were ten hypotheses, they were declared "positive" when the $p(RR) \leqslant 0.005$, which is 0.05/10. Two conditions reached this level of significance: "five or more colds per year" and "red, itchy, watery, sore, dry or inflamed eyes". This latter condition was also found among exposed adults. In addition, high relative risks were seen for "wheezy or whistling chest for most days or nights throughout the year" and "numbness, tingling, prickling, or loss of sensation on arms, hands, legs, and feet". It is tempting to incorporate these into their respective organ-system groups, but this would destroy the a priori basis of the hypotheses.

"Five or more colds per year", and "red, itchy eyes" have been reanalyzed in the same manner as the main hypotheses, and are presented in the next section.

(f) Subanalyses of "Red, itchy eyes" and "Five or more colds per year"

Table 40 shows the subanalyses for red, itchy eyes. There is no evidence of monotonic trend of risk in any of the gradient analyses. Analysis by proximity of residence to the landfill among the exposed children showed no risk reduction by distance from the landfill, either for long-term or short-term residents. Comparison of movers versus non-movers shows evidence of reduced risk among the movers. Comparison of movers with controls shows an elevated risk among movers. The recent residents have a higher incidence

Table 39: Risk of Adverse Health Outcomes Associated With landfill Site Exposure

Secondary Hypotheses - Children

Condition	Confounders in Model	Comparison Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)
1. Hayfever	a,b	exposed	108	17.8	1.11	.25
		controls	75	14.7		
2. Asthma	a	exposed	32	5.0	1.63	.06
		controls	15	2.8		
3. Wheezy or whistling chest for most days or nights throughout the year	a	exposed	12	1.8	5.45	.014
		controls	2	0.4		
4. Five or more colds per year	a,b,c	exposed	105	17.3	1.56	.005
		controls	56	10.8		
5. Nosebleeds (not from injury)	a	exposed	92	15.0	1.47	.012
		controls	54	10.3		
6. Unusual nose irritation or discharge	a	exposed	25	3.8	1.85	.045
		controls	11	2.0		
7. Throat infections or prolonged, irritated sore throat	a,b,d	exposed	114	18.4	1.29	.047
		controls	79	15.1		
8. Red, itchy, watery, sore,dry or inflamed eyes	all	exposed	94	15.1	2.80	$<.001$
		controls	28	5.2		
9. Numbness, tingling prickling, or loss of sensation on arms, hands, legs, feet	a	exposed	7	1.1	4.67	.08
		controls	2	0.4		
10. Problems with physical social or emotional development	a,b	exposed	34	5.2	1.30	.17
		controls	21	3.9		

Table 40: Subanalyses for "Red, Itchy...Eyes"
Children

	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)	Z(linear trend)	p(Z)
1.	Gradient Analysis						
	(a) within 500 Metres	25	11.2	---	---	3.58	.001
	(b) 500-750 Metres	69	17.2				
	(c) controls	28	5.2				
2.	Gradient Analysis (long-term only)						
	(a) within 500 Metres	18	10.5	---	---	1.38	.08
	(b) 500-750 metres	46	15.8				
	(c) controls	19	4.1				
3.	Gradient Analysis (short-term only)						
	(a) within 500 metres	7	13.6	---	---	.61	.27
	(b) 500-750 metres	23	20.9				
	(c) controls	9	11.1				
4.	Migration						
	Movers	26	9.6	.63	.02	---	---
	Non-movers	94	15.1				
5.	Migration						
	Movers	26	9.6	1.80	.017	---	---
	Controls	28	5.2				
6.	Recent Residents	12	5.8	1.78	.11	---	---
	Controls	34	3.8				

rate of red, itchy eyes than the controls, but this does not reach a high level of statistical signficance. Taken together, these latter three results suggest either a migrator bias or an effect of ongoing exposure after the landfill site closed. This issue is addressed further in Section (g) and Table 43, where analyses of health events before and after the end of 1980 are considered separately.

Table 41 shows the subanalyses for five or more colds per year. A monotonic gradient of risk is seen in all three gradient analyses. Borderline levels of statistical significance are seen for the overall analysis and the one confined to long-term residents, but not for the short-term residents. This is as a result of smaller numbers of events and person-years among the short-term residents. The analyses of migrator effects give no evidence of bias. Analysis of recent residents versus controls suggests that those who moved to the landfill area after it closed had been experiencing a higher frequency of colds before they moved into the area.

(g) Analysis of Events Occurring Before 1981, and 1981 - 84

Table 42 shows the reanalyses excluding events occurring after the landfill site was closed. It includes only the "exposed" and "control" children, and should be compared with Table 30. Did the health status differences identified in Table 30 develop before the site was closed? By comparing relative risks, it can be seen that this had occurred for skin, narcotic, and mood conditions. Also, there is evidence that by 1980 there was a difference in the incidence rates of respiratory conditions which began to disappear after the site was closed. Comparison with Table 39 shows that the increased incidence rate of red, itchy eyes had also developed before the site was closed. This was not true for "five or more colds per year", for which differences in incidence rates developed after the site was closed.

Table 41: Subanaylses for "Five or More Colds Per Year"

Children

	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)	Z(linear trend)	p(Z)
1.	Gradient Analysis						
	(a) within 500 Metres	40	18.8	---	---	2.30	.011
	(b) 500-750 Metres	65	16.5				
	(c) controls	56	10.8				
2.	Gradient Analysis (long-term only)						
	(a) within 500 Metres	26	15.9	---	---	2.07	.019
	(b) 500-750 metres	43	14.9				
	(c) controls	43	9.9				
3.	Gradient Analysis (short-term only)						
	(a) within 500 metres	14	28.9	---	---	.60	.27
	(b) 500-750 metres	22	20.7				
	(c) controls	13	16.1				
4.	Migration						
	Movers	49	19.6	1.03	.43	---	---
	Non-movers	105	17.3				
5.	Migration						
	Movers	49	19.6	1.61	.008	---	---
	Controls	56	10.8				
6.	Recent Residents	28	14.0	2.06	.001	---	---
	Controls	76	7.9				

Table 42: Analysis of Events Occurring Before 1981

Children, Exposed versus Controls

	Condition	Groups	N of Events	Incidence (per 1000 person-years)	Relative Risk	p(RR)
1.	Combined Respiratory	exposed	58	20.4	1.75	.008
		controls	31	11.6		
2.	Combined Skin	exposed	53	18.5	1.84	.007
		controls	26	9.7		
3.	Combined Narcotic	exposed	38	13.1	3.70	$<$ .001
		controls	9	3.3		
4.	Combined Mood	exposed	34	11.6	2.06	.020
		controls	16	5.9		
5.	Red, Itchy Eyes	exposed	40	14.0	3.47	$<$ .001
		controls	11	4.1		
6.	Five or more colds per year	exposed	39	13.6	1.25	.197
		controls	26	10.1		

Table 43 presents the relationship between migrators and non-migrators including all events before the end of 1980, then all the events after that time. The period before 1980 represents both the time when the landfill site was open and the time when (virtually) all the migrators were still resident near it. The period after 1980 (1981-84) represents the time after the site was closed and after the migrators had left the area. The table shows that, in all cases, the relative risk (non-migrators/migrators) increases between the two periods. These results suggest a migrator bias, but do not suggest that the main analyses were, in general, conservatively effected by it. In the case of "skin" and "mood" conditions, the "relative risk to 1980" is less than 1.00, suggesting that excluding movers from the main analysis would have reduced the overall risk estimate. But this is not true for "respiratory," "narcotic," and "red, itchy eyes," where the "relative risk to 1980" is greater than 1.00.

The observation of relative risks greater than 1.0 for 1981-84 is not readily explicable. The possibilities are: a "survival effect" related to analyzing the latter part of a follow-up period after early health outcomes have been counted; exposure continued at significant levels after the site closed; the conditions of interest have a latent period between exposure and outcome; and the conditions were unrelated to chemical exposure at the landfill. It should be noted that none of the relative risks for the "1981-84" comparison had 95 percent confidence limits which did not include 1.0. Therefore, all "effects" may represent random variability.

(h) Controls versus recent residents after the landfill closed

Table 44 compares recent residents and controls including only events after the recent residents moved into the area, or after 1980 for the controls. This analysis looked for evidence of ongoing exposure after the site was closed and capped. None was seen for respiratory, skin, narcotic, or mood symptoms. There was borderline evidence of an increased incidence of red, itchy eyes. Because of multiple testing, the credibility of this observation is

Table 43: Migrator Effects (Children) - Relative Risks Before and After 1981 Non-Movers Versus Movers

Condition		Relative Risk ($\frac{\text{Non-movers}}{\text{Movers}}$)	(p)	95% Confidence Limits
1. Combined Respiratory	(a) to 1980	1.10	.72	.80-1.86
	(b) 1981-84	1.49	.13	.87-2.56
2. Combined Skin	(a) to 1980	.91	.72	.54-1.54
	(b) 1981-84	1.23	.33	.80-1.90
3. Combined Narcotic	(a) to 1980	1.09	.79	.56-2.15
	(b) 1981-84	1.68	.13	.84-3.09
4. Combined Mood	(a) to 1980	.53	.027	.31-.93
	(b) 1981-84	1.30	.43	.66-2.56
5. Red, itchy eyes	(a) to 1980	1.37	.35	.69-2.74
	(b) 1981-84	1.60	.09	.89-2.88

* 2-tailed

Table 44: **Events Occurring After 1980, Recent Residents Versus Controls - Children**

	Condition	Groups	N of Events	Incidence per 1000 person-years	Relative Risk	p(RR)*
1.	Combined Respiratory	recent residents	3	7.1	.24	.021
		controls	43	23.4		
2.	Combined Skin	recent	9	21.6	.96	.92
		controls	43	21.3		
3.	Combined Narcotic	recent	1	2.4	.34	.30
		controls	18	8.6		
4.	Combined Mood	recent	3	7.2	1.27	.71
		controls	11	5.2		
5.	Red, Itchy Eyes	recent	7	17.3	2.42	.050
		controls	17	8.2		
6.	Five or more colds per year	recent	10	26.2	2.38	.013
		controls	30	15.2		

* 2-tailed p(RR)

Table 45: Screening Analyses for Hypothesis Generating - Children

	Condition	Groups	N of Events	N without Events	Relative Risk	x^2	$p(x^2)$
1.	Frequent or prolonged bruising	exposed	10	962	.77	.342	.56
		controls	10	740			
2.	Repeated bladder or urinary tract infections	exposed	12	959	1.32	.348	.56
		controls	7	741			
3.	Problems with resistance to disease or seem to get sick easily	exposed	26	941	3.34	8.16	.004
		controls	6	740			

reduced. There was also evidence of increased reports of five or more colds per year. But the credibility of this association was reduced by the evidence in Table 42 which shows that the increased reports of five or more colds per year occurred among the landfill residents after the site was closed, but not before.

(i) Hypothesis-Generating Analyses

Table 45 shows the three conditions which were identified for hypothesis generating. The only one which suggested evidence of an effect was "problems with resistance to disease or seem to get sick easily". Analysis showed that reports of this condition were highly correlated with "five or more colds per year" ($x^2 = 129.8$, $p < 0.00001$).

(j) Conditions Not Thought to be Related to Landfill Site Exposure

Table 46 shows the nine child conditions which were not thought to be related to landfill site exposure. None of these were found in excess among the exposed residents. Several of the conditions had small numbers by the time pre-exposure events were eliminated. There were no other conditions on the questionnaire with sufficient numbers of events to warrant analysis.

Table 46: **Conditions Not Thought to be Related to Landfill Site Exposure - Children**

Conditions	Groups	N of Events	N without Events	Relative Risk	x^2	$p(x^2)$
1. heart murmur	exposed	18	946	1.40	.754	.385
	controls	10	741			
2. food allergies	exposed	32	934	1.17	.314	.575
	controls	21	719			
3. frequent diarrhea	exposed	7	967	.54	1.632	.201
	controls	10	741			
4. frequent constipation	exposed	13	956	2.51	2.795	.095
	controls	4	743			
5. earaches/ear infections	exposed	142	803	1.15	1.279	.258
	controls	94	625			
6. convulsions or seizures with fever	exposed	8	963	.88	.064	.801
	controls	7	739			
7. head injury with loss of conscience	exposed	15	955	.97	.008	.929
	controls	12	738			
8. poisoning requiring admission to hospital	exposed	5	964	.77	.168	.682
	controls	5	744			
9. accident causing bone fracture	exposed	90	871	.99	.003	.954
	controls	70	671			

4. Pregnancy Experience

Tables 47 to 57 outline the pregnancy experience of exposed, control, mover, and recent resident women. Pregnancies were included if they terminated on or after the year of first residence in the house which qualified a woman for the study. Table 47 shows the year when each eligible pregnancy ended. For exposed, control, and mover pregnancies, 1976-80 was the most prevalent period of termination, followed by 1981-1984. Table 48 gives the age of mothers at onset of pregnancy. The mode for exposed and controls was 25-29, followed by 30-34 and 20-24. A higher proportion of control women than exposed were 35 or over (10.4 percent and 4.4 percent, respectively).

Table 49 summarizes the experience with medications, diseases, and chemical exposures during pregnancy. These are reviewed in detail in Tables 50, 51 and 52 respectively. No differences are seen between exposed and controls in terms of overall presence or absence of one or more of each of these pregnancy risk factors. A trend to higher rates of diabetes among control women is noted. Table 53 also shows no differences in smoking and alcohol experience during pregnancy.

Tables 54 to 57 show the results of pregnancy by several outcomes which might be related to environmental exposure. Table 54 shows that the distribution of live births, stillbirths, miscarriages, and abortions did not differ between groups. The trend was towards higher overall misadventure rates in the controls. Table 55 shows no trend toward lower birthweight among the exposed mothers, and Table 56 shows that most of the low birthweight babies in both exposed and control groups were also pre-term. Table 57 shows the site of each reported birth defect and the number of pregnancies resulting in birth defects. No unique or unusual pattern of birth defects was noted, and no increase in total birth defects was seen. Once again, the trend was toward an increased negative result in the controls. In summary, there was no evidence of relationship between residence adjacent to the landfill site and adverse pregnancy experience.

Table 47: **Year Pregnancy Ended for All Eligible Pregnancies***

Study Group	Year Pregnancy Ended				Total
	1972-75	76-80	81-84	Unknown	
Exposed	56	221	109	0	386
Controls	79	160	105	2	346
Movers	26	129	51	1	207
Recent	0	3	36	3	42
Totals	161	513	301	6	981

* Pregnancies were eligible if they terminated during or after the year of first residence in the house which qualified a woman for the study.

Table 48: Age of Mother at Time of Pregnancy

	GROUPS			
Age	Exposed	Controls	Movers	Recent
20	7	1	4	0
20-24	80	43	53	16
25-29	188	161	85	10
30-34	94	105	52	10
35-39	12	32	12	3
40	5	4	1	3
	386	346	207	42

Table 49: Summary of Pregnancy Risk Factors

Risk Factor	Response	Exposed	Controls	Movers	Recent	x^2*	$p(x^2)$
1. Any medications during pregnancy	Yes	66	60	31	10	.008	.93
	No	320	286	172	31		
2. Any diseases during pregnancy	Yes	59	62	34	6	.918	.34
	No	327	284	173	36		
3. Chemical exposure at work during pregnancy	Yes	21	19	7	4	.001	.98
	No	365	327	200	38		

*x_1^2, based on "exposed" versus "controls"

Table 50: Medications/Procedures Occurring During Pregnancy

Question	Response	Groups				x^2*	(p)
		Exposed	Controls	Movers	Recent		
During this pregnancy did ______ take any of the medications or treatments listed on this page?							
(a) dilantin or phenytoin	yes	0	1	0	0	--	--
	no	386	345	207	42		
(b) special x-rays exams such as repeated chest or abdominal x-rays, and barium meal or barium enema	yes	9	7	5	1	.075	.78
	no	377	337	202	41		
(c) hormones/birth control pills	yes	5	3	1	0	--	--
	no	381	343	206	42		
(d) bendectine or other drugs to control nausea	yes	54	50	31	9	.032	.86
	no	332	296	176	33		
(e) warfarin/coumadin	yes	0	0	1	0	--	--
	no	386	346	206	42		
(f) tetracycline	yes	1	2	1	2	--	--
	no	385	344	206	40		
(g) medicine for a thyroid problem	yes	5	2	0	0	-	-
	no	381	344	107	42		

* x^2 for "exposed" versus "controls"

Table 51: **Health Problems During Pregnancy**

Questions	Response	Groups				x^2*	(p)
		Exposed	Controls	Movers	Recent		
During the pregnancy, did ________ have any of the following?							
(a) diabetes	yes	13	21	12	1	3.01	.083
	no	373	325	195	41		
(b) vaginal or pelvic infections	yes	23	18	13	6	.197	.66
	no	363	328	194	36		
(c) an operation requiring an anaesthetic (not at delivery)	yes	4	3	5	0	--	--
	no	382	343	202	42		
(d) German Measles (rubella)	yes	0	1	1	0	--	--
	no	386	345	206	42		
(e) any other serious infection or illness	yes	27	28	12	1	.316	.57
	no	359	318	195	41		

* x^2 for "exposed" versus "controls"

Table 52: **Chemical Exposure at Work During Pregnancy**

Chemical	Response	Groups			
		Exposed	Controls	Movers	Recent
(a) benzene	yes	4	1	2	2
	no	382	345	205	40
(b) chloroprene	yes	4	3	2	0
	no	382	343	205	42
(c) formaldehyde	yes	3	7	0	2
	no	383	339	207	40
(d) mercury	yes	3	6	2	0
	no	383	340	205	42
(e) polychlorinated biphenyls-PCB	yes	0	1	2	0
	no	386	345	205	42
(f) styrene	yes	0	1	2	0
	no	386	345	205	42
(g) toluene	yes	4	2	2	0
	no	382	344	205	42
(h) anaesthetic gases at work	yes	0	7	1	0
	no	386	339	206	42
(i) arsenic	yes	0	1	2	0
	no	386	345	205	42
(j) ethylene oxide	yes	2	5	2	0
	no	384	341	205	42
(k) lead fumes	yes	1	6	1	0
	no	385	340	206	42
l) carbon monoxide	yes	4	4	6	0
	no	382	342	201	42
(m) vinyl chloride	yes	1	1	2	0
	no	385	345	205	42
(n) beryllium	yes	0	1	0	0
	no	386	345	207	42

Table 53: **Health Habits During Pregnancy**

Question	Responses	Groups				x^2	(p)
		Exposed	Controls	Movers	Recent		
1. During this pregnancy, how often did ________ drink alcoholic beverages?	daily	2	3	0	1		
	a few times a week	8	9	11	0	.002*	.97
	a few times a month	9	8	6	0		
	occasionally	169	148	73	15		
	never	197	175	117	26		
2. On the average, how many cigarettes did ________ smoke each day when the pregnancy started?	none	295	272	155	32		
	1-10	28	27	15	4	.629**	.43
	11-20	36	29	12	1		
	20	26	16	25	5		
3. On the average, how many cigarettes was she smoking each day when the pregnancy ended?	none	299	280	165	32		
	1-10	28	23	16	5	1.55**	.21
	11-20	35	26	11	1		
	20	23	15	15	4		

* x^2 based on "never" vs all others (exposed and controls)
** x^2 based on "none" vs all others (exposed and controls)

Table 54: **Outcome of Pregnancy**

Group	Outcomes						
	Live Birth	Twins, one Stillborn	Miscarriage/ Spon. Abortion	Intentional Abortion	Stillborn	x^2	(p)
Exposed	330	0	43	8	5	2.86	.091
Controls	278	2	55	5	4		
Movers	175	0	25	7	0		
Recent	31	0	9	2	0		

* x^2 = live births versus the rest for "exposed" and "controls"

Table 55: Birthweight Among Live Born Infants

Groups		Birthweight			
	1500 gram or less	1500- 2500 grams	2500 grams	x^2	(p)
Exposed	3	19	308	.014 *	.91
Controls	3	15	262		
Movers	1	7	167		
Recent	0	3	28		

* x^2 : 2500 grams versus the rest, "exposed" versus "controls"

Table 56: Birthweight by Month Pregnancy Ended, Exposed Versus Controls

Exposed

month pregnancy ended

		≤7	8	≥9	
	0-1500 grams	2	1	0	3
Birth Weight	1500-2500 grams	4	7	8	19
	2500+ grams	0	20	288	308
		6	28	296	330

Controls

month pregnancy ended

	≤7	8	≥9	
0-1500	1	1	1	3
1500-2500 grams	7	3	5	15
2500+ grams	0	14	247	261
	8	18	253	279

Table 57: Specific Birth Defects by Group*

Group	Neural Tube	Limbs	Face	Genitelia	Cardiac	Chromosomal	Eyes	GI Abdominal	Resp.	Skin	Misc.
Exposed	3	10	2	1	4	2	0	5	1	0	21
Controls	2	7	1	0	6	2	2	4	1	0	17
Movers	0	2	0	0	6	0	2	0	2	1	9
Recent	0	0	1	0	0	0	0	0	0	0	2

Summary Table**

Group	1 Birth defect	No Birth defects	Totals
Exposed	37	349	386
Controls	40	306	346
Movers	19	188	207
Recent	6	36	42

$x^2 = .756$ (based on "exposed" versus "controls")

$p = .38$

* multiple birth defects counted separately.
** multiple birth defects counted together.

5. Medical Chart Abstraction Study

Tables 58 to 63 summarize the results of the medical chart abstraction study, including evidence for reliability of the methods used. Table 58 shows the number of charts abstracted, and the very high completion rates achieved. A total of 340 adults and 207 children were reviewed for a total of 3060 decisions among the adults (340 x 9 conditions) and 1035 decisions among the children (207 x 5 conditions). Inspection of Table 59 shows that a total of 2804 decisions about adults were analyzed (302 related to over-reporting, 2502 related to under-reporting), instead of 3060. For children, 911 decisions were analyzed (181 over-reporting, 730 underreporting) instead of 1035. This exclusion of 8.4 percent of adult decisions and 12.0 percent of child decisions was based on an editing step which intervened between data-collection and analysis. The written description of information found on each chart was reviewed, and where the confirmation categories and methods artificially created over- or under-reporting errors, the decision was excluded. For example, many "under-reports" of "red, itchy, watery, sore, dry or inflamed eyes" resulted from individuals reporting "hayfever" on the questionnaire instead. When selected for medical chart abstraction, "red, itchy eyes" would be "confirmed", based on the descriptions of symptoms found by the abstractor. When this confirmation was merged with questionnaire data, no self-report of "red,itchy eyes" would be found, and the events would appear to be "under-reported". Therefore, such events were excluded from the analysis of medical chart abstraction data.

Table 59 gives the summary tables for over- and under- reporting, listing adults and children separately. A simple x^2 test of the difference in proportions was used to assess recall bias. No evidence of bias was seen in over- or under-reporting among adults. Among children, no evidence of bias was seen for over-reporting, but a trend toward an under-reporting bias was identified. Among exposed children, 16.5 percent of unreported conditions were confirmed or possibly confirmed. Among controls, 22.3 percent of unreported conditions were confirmed or possibly confirmed.

Table 58: Completion Rates for Chart Abstractions

	Sampling Group				
	Exposed		Control		Total
	Adult	Child	Adult	Child	
A. Charts Assigned	232	137	134	78	581
B. Respondents with 2 charts	8	3	1	1	13
C. Respondents assigned (A - B)	224	134	133	77	568
D. Respondents NOT Completed	5	3	2	1	11
E. Respondents Completed	219	131	131	76	557
F. Completion Rate (E - C x 100)	97.8%	97.8%	98.5%	98.7%	98.1%

Table 59: Medical Chart Abstraction Study-Overall Comparisons of Under Reporting and Over Reporting

(a) Adult Over Reporting

	Reported Condition		
	Confirmed/ Possibly	Not Confirmed	
Exposed	133	80	213
Controls	54	35	89
	187	115	302

$x^2 1 = .083$
$p = .772$

(b) Adult Under Reporting

	Conditions not Reported		
	Not Confirmed	Confirmed/ Possibly	
Exposed	1404	172	1576
Controls	821	105	926
	2225	277	2502

$x^2 1 = .107$
$p = .757$

(c) Child Over Reporting

	Reported Condition		
	Confirmed/ Possibly	Not Confirmed	
Exposed	65	55	120
Controls	39	22	61
	104	77	181

$x^2 = 1.58$
$p = .211$

(d) Child Under Reporting

	Conditions not Reported		
	Not Confirmed	Confirmed/ Possibly	
Exposed	389	77	466
Controls	205	59	264
	594	136	730

$x^2 = 3.77$
$p = .052$

Tables 60 and 61 give the results of the reliability workshops which occurred before fieldwork began and after it was completed. The analysis of variance was based on a 10 abstractor by 46 decision table (4 adult charts x 9 decisions plus 2 child charts x 5 conditions). Confirmations were scored "1", possible confirmations "2", and non-confirmations "3". Subanalyses were made on the adult data only. There were too few points to analyze the child data separately. The intraclass correlation[26] was calculated according to the formula at the bottom of Table 60. Although there is no absolute scale for judging agreement, an intraclass correlation between 0.60 and 0.80 would indicate a moderately high level of inter-abstractor reliability. Comparison of Tables 60 and 61 show that the intra-class correlation stayed in that range during both workshops, although it dropped slightly from the first workshop to the second.

Tables 62 and 63 explore intra-abstractor reliability by assessing the agreement between specific decisions made in each workshop. Table 62 summarizes the overall test-retest reliability in a 3 x 3 contingency table. Overall agreement was 87 percent, and the unweighted Kappa[27] was 0.76 (95 percent confidence limits .70 - .82). This represents a moderately high level of intra-abstractor agreement. Moreover, the proportion of "above diagonal" and "below diagonal" disagreements was similar. This suggests that there was no "learning effect" during the chart abstraction study which led to a systematic change in the way the abstractors made their decisions.

Table 63 summarizes the test-retest reliability of each abstractor. Abstractor performance ranged from acceptable (K = .52) to excellent (K = .96). In summary, the methods of medical chart abstraction appear to have a high level of intra- and inter- abstractor reliability. This lends credibility to the assessment of recall bias for which these methods were developed.

Table 60: Between-Abstractor Reliability-Medical Chart Abstraction Procedures

Workshop I (Before Field Work Began)

(a) Adult and Child Conditions Combined

	Source of Variation	Sum of Squares	DF	Mean Square	Intraclass Correlation
1.	Between Decisions	274.6	45	6.102	.73*
2.	Within Decisions	93.5	414	.226	
	(a) Between Abstractors	5.7	9	.633	
	(b) Residual	87.8	405	.217	

(b) Adult Conditions Only

	Source of Variation	Sum of Squares	DF	Mean Square	Intraclass Correlation
1.	Between Decisions	191.4	35	5.469	.76*
2.	Within Decisions	54.2	324	.167	
	(a) Between Abstractors	1.99	9	.221	
	(b) Residual	52.2	315	.166	

* Intraclass Correlation $= \frac{\hat{\theta}}{1+\hat{\theta}}$ where $\hat{\theta} = \frac{\text{MS between decisions} - \text{MS within decisions}}{(\text{N of Abstractors})(\text{MS within decisions})}$

Table 61: Between-Abstractor Reliability-Medical Chart Abstraction Procedures

Workshop 2 (After Field Work Was Completed)

		Sum of Squares	DF	Mean Square	Intraclass Correlation
	(a) Adult and Child Conditions Combined				
1.	Between Decisions	242.1	45	5.381	
2.	Within Decisions	113.9	414	.275	.65
	(a) Between Abstractors	15.9	9	1.770	
	(b) Residual	98.0	405	.776	
	(b) Adult Conditions Only				
1.	Between Decisions	156.4	35	4.468	
2.	Within Decisions	77.5	324	.239	.64
	(a) Between Abstractors	11.1	9	1.229	
	(b) Residual	66.4	359	.651	

Table 62: **Test-Retest Reliability of medical Chart Abstractions**

All Abstractors: Comparison of Workshop I with Workshop 2

		2nd Workshop			
		Confirmed	Possibly Confirmed	Not Confirmed	Totals
1st Workshop	Confirmed	110	7	17	134
	Possibly Confirmed	5	29	7	41
	Not Confirmed	8	15	262	285
		123	51	286	460

Overall Agreement = 87%
"Chance" Agreement = 47%
Kappa (unweighted) = .76 quadratic weighted = .81
CI_{95}= .70-.82
Z(k 0)= 20.56 p(Z) .001
Proportion of "above diagonal" disagreements = 6.7%
Proportion of "below diagonal" disagreements = 6.1%

Table 63: **Test-Retest Reliability of Medical Chart Abstractions**

By Individual Abstractors: Comparison of Workshop 1 with Workshop 2

Abstractor	Overall Agreement	Chance Agreement	Kappa(k) (unweighted)	95% C.I.*	Z(k 0)	p(Z)
1.	85%	43%	.73	.55-.91	6.6	<.001
2.	80%	59%	.52	.28-.76	4.5	<.001
3.	87%	72%	.54	.25-.83	4.4	<.001
4.	83%	45%	.69	.49-.89	5.8	<.001
5.	91%	41%	.85	.71-.99	7.5	<.001
6.	93%	42%	.93	.81-1.0	7.9	<.001
7.	80%	46%	.64	.45-.83	6.1	<.001
8.	83%	44%	.69	.50-.88	6.1	<.001
9.	98%	45%	.96	.88-1.0	8.2	<.001
10	91%	45%	.84	.70-.98	7.2	<.001

* C.I. - confidence interval

6. Current Health Status

Table 64 through 68 relate to the current prevalence of various health problems amongst the exposed group and controls. These analyses were carried out to fulfill objective three of this study, identified in the introduction of this report: to assess whether or not any health problems found in excess amongst the exposed residents would be likely to continue to affect their wellbeing over time.

Table 64 shows the current prevalence of the health problems found in the main analysis in Table 14 grouped by organ system. The events included in the main analysis have been divided between those where the study respondent reported still having the condition at time of interview and those where they reported no longer having the condition. The data in this table can be used to answer two questions.

1. Have the health conditions which began after the first residence in the exposed or control community persisted to a greater extent amongst the exposed residents than the controls?

2. Is the current prevalence of the health problems of interest greater amongst the exposed group than the controls?

The former question can be answered simply by comparing the proportion of residents in each study group who reported still having the condition versus those no longer having the condition. The latter question can be answered by comparing proportions of those reporting still having the condition with the combination of those who never had the condition and those who had it but did not still have it at the time of interview. Table 64 shows that the proportion of exposed adults reporting still having a condition is higher than the controls for the respiratory group only. No differences in the rates of persistence were noted for skin, narcotic, or mood conditions. On the other

Table 64: Current Prevalence of Health Problems by Organ-system in the Main Analysis - Adults

Condition	Groups	First Had Condition After Residence in Landfill/Control Area		Did not Have Condition	x^2	$p(x^2)$
		Still Have it	Don't Have it Now			
1. Combined Respiratory	exposed	105	44	848	30.53*	$<$.001
	controls	47	44	748	--	--
	movers	37	12	420	8.62**	.003
	recent	11	4	272		
2. Combined Skin	exposed	113	17	867	10.50*	.003
	controls	58	10	771	---	---
	movers	45	10	414	.10**	.751
	recent	10	0	277		
3. Combined Narcotic	exposed	159	11	827	29.55*	$<$.001
	controls	64	3	772	---	---
	movers	67	14	388	.34**	.560
	recent	17	1	269		
4. Combined Mood	exposed	122	7	868	13.87*	$<$.001
	controls	59	7	773	---	---
	movers	57	6	403	1.76**	.185
	recent	11	2	274		

* x^2 = exposed versus controls, for "still have it", and "don't have it not"/ "did not have condition" combined.

** x^2_1 = exposed versus controls, for " still have it", and "don't have it now".

hand, the current prevalence of the conditions of interest was increased amongst exposed adults for all four organ system groups of conditions.

The same analysis was carried out on the individual conditions contributing to the organ system groups. This included all individual conditions where the p (relative risk) was less than or equal to .01. In each case, a current prevalence of the condition was greater amongst the exposed than the controls. This was also true for "red, itchy eyes" which is listed in Table 65. Once again, there was little evidence of a higher rate of persistence of individual conditions amongst the exposed residents. The only individual condition for which increased persistence was noted was for "cough and phlegm".

Tables 66 and 67 present parallel analyses to those in Table 64 and 65, only related to children. On Table 66, evidence of increased persistence among exposed children is confined to the respiratory group. Yet all four organ system groups show an increased current prevalence among the exposed. Table 67 shows the individual contributing conditions in a manner similar to Table 65 for adults. Evidence of increased persistence of an individual condition amongst exposed children is found only for "five or more colds per year". An increased current prevalence is noted for all conditions except "recurrent or severe problems with boils, warts, cysts".

The results of the Canada Health Survey items are presented in Table 68 as a check on overall health status. These questions assess the current prevalence of a broad range of long term health problems not necessarily related to environmental exposures. All Canada Health Survey rubrics were used precisely the same way as the Canada Health Survey itself. Table 68 presents the 14 conditions for which sufficient data were available for analysis for either adults or children. In general, the data do not show major differences between the exposed and control groups for either adults or children. The differences found in the main analyses related to narcotic symptoms are reflected in the rubric "recurrent migraine headaches" among

Table 65: Current Prevalence of Individual Health Problems - Adults

Condition	Groups	First Had Condition After Residence in Landfill/Control Area		Did Not Have Condition	x^2	$p(x^2)$
		Still Have It	Don't Have It Now			
1. attacks of bronchitis	exposed	21	22	912	3.95*	.046
	controls	8	13	787	.66**	.42
2. shortness of breath	exposed	42	6	924	7.40*	.007
	controls	17	4	813	.51**	.48
3. cough and phlegm	exposed	60	28	884	13.76*	.0002
	controls	21	32	775	11.04**	.0009
4. recurrent or severe problems with scaly, dry, or itchy skin	exposed	57	1	905	10.85*	$<.001$
	controls	22	0	795	-	-
5. frequent or severe headaches	exposed	99	7	808	17.60*	.00003
	controls	40	1	730	-	$.44^+$
6. frequent dizziness or blurred vision	exposed	31	7	954	6.65*	.0099
	controls	11	2	825	-	1.0^+
7. constant fatique, lethargy, drowsiness	exposed	60	3	923	15.89*	.00007
	controls	19	3	815	-	$.33^+$
8. frequent feelings of anxiety or depression	exposed	56	6	904	14.72*	.0001
	controls	18	5	803	2.17**	.141
9. frequent feelings of irritability	exposed	46	2	935	9.43*	.002
	controls	17	3	815	2.43**	.118
10. red, itchy eyes	exposed	61	14	894	5.45*	.0195
	controls	31	11	767	.907**	.341

$*x^2_1$ = exposed versus controls for "still have it" and "don't have it now"/"did not have conditions" combined.
$**x^2_1$ = exposed versus controls, for "still have it" and "don't have it now".
$^+$ = Fischer's exact test, 2-tailed.
(Individuals reporting event before first residence at the landfill or control home have been excluded from the anaysis.)

Table 66: Current Prevalence of Health Problems by Organ-system in the Main Analysis - Children

Condition	Groups	First Had Condition After Residence in Landfill/Control Area		Did not Have Condition	x^2	$p(x^2)$
		Still Have it	Don't Have it Now			
1. Combined Respiratory	exposed	81	38	855	9.82*	$<.001$
	controls	34	40	678	--	--
	movers	19	21	411	9.27**	.002
	recent	1	4	272		
2. Combined Skin	exposed	98	45	831	4.86*	.014
	controls	53	16	683	---	---
	movers	42	10	399	1.56**	.212
	recent	7	2	166		
3. Combined Narcotic	exposed	80	8	886	17.68*	$<.001$
	controls	25	2	725	---	---
	movers	20	4	427	.07**	.786
	recent	1	0	174		
4. Combined Mood	exposed	75	4	895	7.00*	.004
	controls	25	2	725	---	---
	movers	33	2	416	.21**	.644
	recent	3	0	172		

* x^2 = exposed versus controls, for "still have it", and "don't have it now"/"did not have condition" combined.

** x^2_1 = exposed versus controls, for " still have it", and "don't have it now".

Table 67: Current Prevalence of Individual Health Problems - Children

Condition	Groups	First Had Condition After Residence in Landfill/Control Area		Did Not Have Condition	x^2	$p(x^2)$
		Still Have It	Don't Have It Now			
1. cough and phlegm	exposed	43	22	898	7.75*	.0053
	controls	15	16	716	2.77**	.096
2. recurrent or severe problems with boils, warts, cysts	exposed	29	32	909	.833*	.36
	controls	17	5	726	5.79**	.016
3. frequent or severe headaches	exposed	69	7	890	14.85*	.00012
	controls	22	2	725	.02**	.896
4. frequent feelings of hyperactivity, restlessness trouble sitting still	exposed	34	2	919	6.96*	.008
	controls	11	0	730		1.0+
5. red, itchy eyes	exposed	73	19	862	22.05*	.00001
	controls	18	10	715	2.66**	.103
6. five or more colds per year	exposed	79	26	840	14.94*	.0001
	controls	27	27	673	10.22**	.0014

*x^2_1 = exposed versus controls for "still have it" and "don't have it now"/"did not have conditions" combined.
**x^2_1 = exposed versus controls for "still have it" and "don't have it now".
+ = Fischer's exact test, 2-tailed.
(Individuals reporting event before first residence at the landfill or control home have been excluded from the analysis.)

adults. There are no differences among the majority of other chronic diseases listed. The only unexpected difference was in relation to "serious trouble with bones and joints" among adults. This difference is unexpected and unexplainable on the basis of landfill site exposure. It may represent a random false positive.

In summary, the conditions found in excess amongst the exposed residents were still found in excess at time of interview. However, the rate of persistence of these conditions was no greater among exposed than controls for 3 of the 4 main organ system groups. It is likely that the rate of persistence of the conditions found in excess during exposure to the landfill site will continue to diminish with time.

Table 68: Current Prevalence of Long-Term Health Problems (Canada Health Survey Items)

	Condition	Adults		Children	
		Odds Ratio*	(p)	Odds Ratio*	(p)
1.	Anemia	0.76	.38	-	-
2.	Skin Allergies	1.32	.065	1.19	.40
3.	Hayfever or other allergies	.82	.062	.98	.88
4.	Asthma	1.36	.21	1.17	.61
5.	Arthritis or rheumatism	.91	.51	-	-
6.	Diabetes	.92	.82	-	-
7.	Emphysema or chronic bronchitis	1.82	.035	1.40	.35
8.	Any emotional disorders excluding mental retardation	1.13	.78	-	-
9.	High blood pressure	1.10	.59	-	-
10.	Heart Disease	1.18	.55	-	-
11.	Stomach Ulcer	1.08	.77	-	-
12.	Thyroid trouble or goitre	1.43	.33	-	-
13.	Recurring migraine headaches	1.51	.005	2.70	.005
14.	...serious trouble with joints and bones	1.84	.0001	1.22	.66

* age - and sex-adjusted by logistic regression, $\frac{\text{exposed}}{\text{controls}}$

VI. DISCUSSION

Tables 69 and 71 summarize the results of hypothesis testing for adults and children, respectively. Tables 70 and 72 are guides to the sources of information found in the summary tables.

Table 69 identifies nine criteria for assessing the validity of the association between landfill site exposure and the conditions of interest, based on the following parameters: strength of association, consistency with the workers study, gradient, lack of migrator bias, risk occurring first when site was open, no evidence that less healthy people moved to the landfill area, specificity, and absence of recall bias. These latter two criteria apply generally to all conditions rather than to each condition individually. Specificity was assessed by looking for associations between landfill exposure and conditions not believed to be related to an environmental exposure. The investigation of recall bias was based on comparisons of questionnaire responses with medical records, according to defined categories of confirmation and non-confirmation. Strength of association was determined by the magnitude of relative risk, and the level of statistical significance of the findings. Migrator bias was assessed by comparing health events among movers versus non-movers separately for those events occurring before the landfill site closed and then after it closed. Inspection of Table 69 shows that all criteria were completely fulfilled by the "combined narcotic" group of conditions. "Red, itchy eyes" fulfilled the fewest criteria, while the respiratory, skin, and mood conditions fulfilled most criteria. These results imply that the evidence of a cause and effect relationship between landfill site exposure and the narcotic conditions was greatest, followed by respiratory, skin, and mood conditions. Evidence of causation was weakest for "red, itchy eyes".

The evidence relating to children is summarized in Table 71. The same criteria were used, except for "consistency with the workers study" which was omitted. This omission was made because age is a powerful predictor of health status. Therefore, an absence of consistency between adults and children would

Table 69: Summary of the Results of Hypothesis Testing - Adults

Criteria for Assessing the Association	Condition				
	Resp.	Skin	Mood	Narc.	Red,Itchy Eyes
1. Was the relative risk on the main analysis greater than 1.5?	Yes	Yes	Yes	Yes	Yes
Was it greater than 2.0?	No	No	No	Yes	No
2. Was the probability value for the relative risk in the main analysis less than 0.01?	Yes	Yes	Yes	Yes	Yes
Was it less than 0.001?	Yes	Yes	Yes	Yes	No
3. Were these results consistent with the workers study?	Yes	Yes	Yes	Yes	No
4. Was there a monotonic gradient of risk comparing residents within 500 metres of the site, those further away, and controls?	Yes	Yes	Yes	Yes	Yes
Was the gradient found primarily among long-term residents?	Yes	Yes	Yes	Yes	Yes
Was there a gradient within the exposed group only, among long-term residents?	Yes	No	Yes	Yes	Yes
5. Was there evidence that migrator bias might explain the differences between exposed and controls on the main analyses?	No	No	No	No	No
6. Did the landfill site attract people who were less healthy than controls with respect to this condition?	No	No	No	No	No
7. Had the risk developed before the landfill site was closed?	Yes	Yes	Yes	Yes	Yes
8. Were increased risks among exposed residents confined to the conditions hypothesized?	No general trend to increased risks among non-hypothesized conditions, but there were a few associations.				
9. Was there any evidence of over-reporting or under-reporting recall bias on medical chart abstraction?	There was no evidence of over- or under-reporting recall bias.				

Table 70: Guide to the Tables Summarized in Table 69

Criteria for Causation	Tables
1. and 2.	Table 14 (page 61) Table 23 (page 74)
3.	Table 1 (page 10)
4.	Table 16 (page 64) Table 17 (page 65) Table 18 (page 66) Table 19 (page 68) Table 24 (page 75)
5.	Table 26 (page 79)
6.	Table 22 (page 73) Table 24 (page 75)
7.	Table 25 (page 77)
8.	Table 29 (pages 83 & 84)
9.	Table 59 (page 123)

Table 71. Summary of the Results of Hypothesis Testing - Children

Criteria for Assessing the Association	Condition					
	Resp.	Skin	Mood	Narc.	Red itchy eyes	5^+ Colds
1. Was the relative risk on the main analysis greater than 1.5?	No	Yes	Yes	Yes	Yes	Yes
Was it greater than 2.0?	No	No	Yes	Yes	Yes	No
2. Was the probability value for the relative risk in the main analysis less than 0.01?	No	Yes	Yes	Yes	Yes	Yes
Was it less than 0.001?	No	Yes	Yes	Yes	Yes	No
3. Was there a monotonic gradient of risk comparing residents within 500 metres of the site, those further away, and controls?	No	Yes	No	Yes	Yes	Yes
Was the gradient found primarily among long-term residents?	Yes	Yes	Yes	Yes	No	No
Was there a gradient within the exposed group only, among long-term residents?	No	No	No	No	No	--
4. Was there evidence that migrator bias might explain the differences between exposed and controls on the main analysis?	No	No	No	No	No	No
5. Did the landfill site attract people who were less healthy than controls with respect to this condition?	No	No	No	No	No	Yes
6. Had the risk developed before the landfill site was closed?	Yes	Yes	Yes	Yes	Yes	No
7. Were increased risks among exposed residents confined to the conditions hypothesized?	No increased risks were found among non-hypothesized conditions.					
8. Was there any evidence of over-reporting or under-reporting recall bias on medical chart abstractions	Trend to over-reporting of reported conditions and lower rates of under-reporting among exposed child. Not statistically significant.					

Table 72: Guide to the Tables Summarized in Table 71.

Criteria for Assessing the Association	Tables
1. and 2.	Table 30 (page 86) Table 39 (page 98)
3.	Table 32 (page 89) Table 33 (page 90) Table 34 (page 91) Table 35 (page 92) Table 40 (page 99) Table 41 (page 101)
4.	Table 43 (page 104)
5.	Table 38 (page 96) Table 40 (page 99) Table 41 (page 101)
6.	Table 42 (page 102)
7.	Table 46 (page 108)
8.	Table 59 (page 123)

not have been a meaningful negative result. Once again, the evidence among the narcotic conditions is strongest. The quality of evidence relating to skin conditions, mood conditions, and "red, itchy eyes" was intermediate. The quality of evidence relating to respiratory conditions and "5 or more colds per year" was poor. Evidence of a valid association between landfill site exposure and respiratory conditions was only found on sub-analyses and not on the main analysis. Evidence that "five or more colds per year" was associated with landfill site exposure primarily related to the time after the site had been capped. Therefore, these latter two conditions do not appear to be related to landfill site exposure among children.

The strength of the evidence for valid associations between residence adjacent to the landfill site and conditions identified in Tables 69 and 71 is reduced by three principal problems. These are: the high refusal rate among the control population; socioeconomic status differences between the study groups; and the fact that the conditions found in excess are imprecisely defined and potentially interchangeable with other conditions. Offsetting these problems are the multiple criteria used to assess the hypotheses which were identified and evaluated according to preset rules.

In summary, the association between residence adjacent to the landfill site and an increased incidence of certain "narcotic", "mood", "skin", and "respiratory" conditions among adults appears to be valid. The evidence related to "red, itchy eyes" is less strong but cannot be ruled out. Among children, a valid association can be asserted for "narcotic", "skin", "mood", and "red, itchy eyes". The problem, however, is that the causative agent or agents have not been identified. Two competing causes may be proposed:

1. some airborne contact with a combination of vapours, fumes, and particulate matter emanating from the landfill site, and with direct skin exposure from recreational activities in and around the landfill.

2. the perception of exposure and, therefore, of risk may have led to an increased tendency on the part of exposed residents to notice new health problems, become concerned about them and subsequently report them in a health survey..

The evidence from this study permits an indirect assessment of which causal mechanism applies. There are six lines of reasoning which suggest a chemical mechanism:

1. The gradient of risk by proximity to the landfill site would be difficult to explain on the basis of perception of risk alone. While perception of risk may be directly related to proximity to the landfill, it is difficult to believe that the relationship could be precise enough to explain to gradient by house distance from the landfill and the fact that the gradient effect involved only long-term residents among the adults.

2. The symptoms and the organ-systems affected were biologically plausible on the basis of exposure to substances known to be present in the landfill. It is difficult to explain how a perceptual mechanism could have selected for those conditions which could also be related to environmental exposure without including more of the other conditions on the questionnaire which could not be plausibly related to environmental exposure.

3. The consistency of symptoms between workers and residents was remarkable, considering the lack of contact between them and the differing attitudes to the potential for risk expressed by members of the two groups.

4. Despite the fact that a previous health survey of a minority of residents was conducted by the residents themselves, and the results published, the conditions found in excess in our study did not confirm their results. Had our study confirmed the previous study's results, the most likely explanation would have been that the residents had learned the symptoms through publicity. Rather, the conditions found in excess in our study were largely unrelated to those found in excess on the residents' original survey.

5. Were there to have been a significant perceptual component to the associations found in our study, this ought to have been reflected in evidence of recall bias on medical chart abstraction. This was not the case.

6. Tables 64 through 67 demonstrate that, in general, the conditions which developed during the period when the landfill was open are disappearing at a similar rate among exposed residents and controls. Moreover, there was no evidence of greater levels of respiratory disability among the exposed residents despite increased reports if respiratory symptoms. These findings are not characteristic of a learned illness behaviour, wherein it would be expected that increased chronicity and disability would accompany symptoms.[28]

In addition, there are four lines of reasoning which strengthen the case for a perceptual mechanism.

1. There has never been any evidence presented which shows that residents or workers were exposed to airborne concentrations of the substances of interest sufficient to cause the health problems found in excess in this study. Since nuisance odours were and are still a frequent problem in the area, there is a basis to assume that perception of exposure, rather than exposure as such, was the principal causative factor.

2. The health problems found in excess in this study can all be well explained by behavioural mechanisms. None uniquely requires chemical exposure and none is based on evidence of human tissue damage.

3. The same objections which were raised regarding the validity of the association between landfill site exposure and the health problems of interest can also be raised as issues in causation. In particular, the socioeconomic status differences between groups and the unblinded study design may influence perceptual and behavioural factors that affect one's experience and recall of symptoms. Review of medical records would not necessarily be able

to detect such an effect, assuming that individuals did in fact seek medical assistance for their identified health problems.

4. The analyses relating to migrator bias did demonstrate that non-migrators tended to have higher rates of first onset of health problems than migrators, after the landfill had been closed. Three hypotheses were advanced to explain this observation in section V2(g) and V3(g) of this report. One hypothesis suggested that location of residence (and thus, perception of exposure) is the crucial determining factor, and not exposure to vapours, fumes, and dusts.

While some of the lines of reasoning presented in favour of each causal mechanism are speculative, those in support of a chemical mechanism are based on the fulfillment of preset analytic criteria for the study, which could just as easily have gone unfulfilled. However, examples exist where residents exposed to environmental chemical contamination repprted excess symptoms in a way which would have appeared to point to the contamination as a cause; only to find that the original evidence of environmental contamination was incorrect, and had not occurred.[21] On the other hand, the first and second arguments for a perceptual mechanism are based on inherent limitations of the study which could not have been overcome by any changes in study design. The fourth argument for a perceptual mechanism is based on the last four years of a survival analysis, excluding the first nine years. The simplest explanation for the results so obtained would be a survival effect, and not a phenomenon regarding perception of exposure. In the end, the strongest argument for a perceptual mechanism is the familiar evidence that psychological distress is an important correlate of perceived health status.[29] The authors of this report believe that the lines of reasoning supporting chemical causation are more convincing than those which support a perceptual mechanism. It is recognized that both mechanisms could variously contribute to each group of reported symptoms to a different degree, but the nature of such relationships is purely a matter of speculation.

This study did not produce any evidence of adverse reproductive outcomes related to exposure to the landfill site. This is a very significant negative finding which should provide substantial re-assurance. There was no evidence of increases in major chronic diseases among exposed residents. The question of increased cancer risks cannot be addressed by this study because a sufficient follow-up period has not occurred between the time of first residence (1972) and the study date (1984). In order to answer this question it would require following up the cohort of exposed residents over the next 10-20 years to assess their cancer experience through incidence and mortality registries.

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APPENDIX

Results of Health Study

done by

Upper Ottawa Street
Residents' Association

November, 1979

November 16, 1979.

ANALYSIS OF DATA:

UPPER OTTAWA DUMP AREA VS CONTROL SURVEY

1. Raw Counts: 24 Signs, Symptoms, or Diseases.

Rules of Acceptance of Counts:

1. All reports counted, whether they are described as being before current residence or not.

2. When individuals in a family were listed as having the condition, each was counted. An unqualified "yes" answer was taken as one count (report).

3. All obvious misdiagnoses excluded.

		CONTROL SURVEY	DUMP SURVEY
Total residents:		134	127
1.	Skin rash	13	29
2.	Asthma	7	7
3.	Bronchitis	5	8
4.	Emphysema	0	0
5.	Frequent Colds	9	32
6.	Kidney Problems	1	9
7.	Freq. Bladder Inf.	7	11
8.	Nervous Breakdown	0	2
9.	Hyperactivity	0	1
10.	Freq. Sore Throat	4	55
Total residents:		128 (1 family not included)	127
11.	Epilepsy	0	2
12.	Migraines	8	4
13.	Other Headaches (freq)	3	30
14.	Nervousness	7	19
15.	Mental Retardation	0	0
16.	Heart Problems	1	1
17.	Arthritis	8	8
18.	Bone Problems	1	0
19.	Paget's Disease	0	0
20.	Gall Bladder	1	1
21.	Cancer	0	0
22.	Bleeding	4	20
23.	Freq. Earaches	3	47
24.	Hearing Loss	1	4

On the basis of these crude rates, certain conditions will be excluded from further analysis:

Emphysema
Nervous Breakdown
Hyperactivity
Gall Bladder Disease
Mental Retardation
Bone Problems
Heart Problems
Cancer
Hearing loss
Epilepsy

cont'd.....

Among the remainder, several conditions have similar crude counts between the Upper Ottawa Dump Survey and the Control Survey, or else appear more commonly in the Control Survey. These include:

1. Asthma
2. Bronchitis
3. Migraines
4. Arthritis

These will be divided by report of history prior to residence in survey and where applicable, by crude age ["adult" vs "child"].

1. Asthma:

	Control Survey	Upper Ottawa Dump Survey
% Adults with complaint	1.5% (2)	1.6% (2)
% Children with complaint	3.7% (5)	3.9% (5)
% with complaint previous to current residence	1.5% (2)	3.1% (4)
% with no history of complaint before current residence	3.7% (5)	2.4% (3)

2. Bronchitis:

	Control Survey	Upper Ottawa Dump Survey
% adults with complaint	3.0% (4)	3.9% (5)
% Children with Complaint	0.7% (1)	2.4% (3)
% with complaint previous to current residence	2.2% (3)	3.1% (4)
% with no history of complaint before current residence	1.5% (2)	3.1% (4)

3. Migraines:

	Control Survey	Upper Ottawa Dump Survey
% with complaint before current residence	0.8% (1)	0.8% (1)
% with no history of complaint before current residence	5.5% (7)	2.4% (3)

4. Arthritis:

	Control Survey	Upper Ottawa Dump Survey
% with complaint before current residence	5.5% (7)	1.6% (2)
% with no history of complaint before current residence	0.8% (1)	4.7% (6)

Conclusions: In the case of asthma, bronchitis, and migraines no obvious differences in the "control" and "dump" surveys exist. In view of the very small numbers involved, these will be discarded from further analysis.

In the case of "arthritis" there appears to be a difference in the rates before and subsequent to current residence. However, the diagnostic standard for arthritis was very poor: including aches and pains, gout, muscle cramps, etc. This was particularly evident in the responses from the Upper Ottawa Survey. For this reason it too should be excluded from further analysis.

cont'd.....

This leaves 9 conditions for detailed analysis.

	Condition		Crude Relative Risk	
1.	Skin Rash		2.35	
2.	Frequent Colds		3.75	
3.	Kidney Problems	Combined *	11.61	Combined*2.64
4.	Frequent Bladder Infections		1.66	
5.	Frequent Sore Throats		14.51	
6.	Other headaches, frequent		10.01	
7.	Nervousness		2.75	
8.	Bleeding		5.04	
9.	Frequent Earaches		15.79	

* These two values were combined because the written comments on the questionnaire forms indicates some confusion between them.

Summary: Without further analysis (which in view of the limitations of the data-collection method would be uncalled-for) it appears that complaints of earaches, sore throats and headaches are more frequent among the residents interviewed in the Upper Ottawa Dump Survey, when compared to those interviewed in the Control Survey.

Possible Target Sites and Effects of Chemicals Identified at Elevated Levels in Samples Taken In or Near Upper Ottawa Street Landfill

Chemicals	Effects Eye irritation	Eye damage	Skin irritation	Skin damage (chloracne)	Allergic sensitization	Upper respiratory tract irritation	Lung damage	Liver damage	Kidney damage	Central nervous system depression	Central nervous system damage	Peripheral nervous system damage	Blood cell disorders	Methemoglobinemia	Immunological effects	Spleen damage	Thymus damage	Cardiovascular effects	Gastrointestinal effects	Pancreatic damage	Endocrine disorders	Bone disorders	Reproductive effects	Embryotoxicity	Teratogenicity	Mutagenicity	Carcinogenicity	Tumor promotion
Organic Chemicals																												
Aliphatic alcohols	+		+			+		+	+		+																	
Alkyl benzenes	+		+			+				+																		
Alkyl ketones	+		+					+	+	+								+										
Alkyl phenols	+		+			+	+	+	+	+	+					+		+	+	+								
Aniline														+													+	
Aromatic acids	+		+																									
Benzene	+		+							+			+		+			+								+	+	
Benzothiazole					(+)																							
Carboxylic acids	+		+			+																						
Cresols	+		+																									
1,4 Dichlorobenzene	+		+			+		+	+				+															
1,2 Dichloroethene	+																											
Dichloromethane	+		+					+		+														+				
1,4-Dioxane	+		+			+		+	+																		+	
PAHs	+	+	+			+		+					+											+	+		+	+
PCBs				+			+	+							+		+		+				+	+	+	+	+	
Phenol	+		+			+	+	+	+	+	+	+						+	+									+
Phthalate ester [Di(2-ethylhexyl)-]	+		+					+															+				+	
Phthalate esters (other)	+		+																									
Tetrachloroethene	+		+			+		+	+	+									+					+			+	
Tetrahydrofuran			+			+		+	+	+								+										
Trichloroethene	+		+							+					+			+								+	+	
Inorganic Chemicals																												
Aluminum																			+			+						
Chromium	+		+		+	+	+						+						+									
Copper								+	+		+					+			+									
Iron							+												+									
Lead									+		+	+	+		?			+			+		+	+			+	
Manganese					+						+																	
Nickel					+		+	+	+	+									+				+				+	
Zinc			+					+					+						+				+					

NOTES:
a. Parentheses () indicate that no data were found for the particular chemical, but closely related chemicals have the effect noted. A question mark (?) indicates that the evidence for a particular effect is not conclusive.
b. Where classes of chemicals are indicated, not all members of the class cause all the effects noted.

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